AD A030638

12

B.S.

TECHNICAL REPORT H-76-14

EFFECTS OF HURRICANE SURGE BARRIER ON HYDRAULIC ENVIRONMENT, JAMAICA BAY NEW YORK

Hydraulic Model Investigation

by

Robert F. Athow, Jr.

Hydraulics Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

September 1976
Final Report

Approved For Public Release; Distribution Unlimited

Prepared for U. S. Army Engineer District, New York
New York, New York 10007

D D C
OCT 12 1976

Destroy this report when no longer needed. Do not return
it to the originator.

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
Technical Report H-76-14 (14) WES-TR-H-76-14

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
(6) EFFECTS OF HURRICANE SURGE BARRIER ON HYDRAULIC ENVIRONMENT, JAMAICA BAY, NEW YORK; Hydraulic Model Investigation

5. TYPE OF REPORT & PERIOD COVERED
(9) Final report, Mar 67-Jul 75

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
(10) Robert F. Athow, Jr

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
U. S. Army Engineer Waterways Experiment Station
Hydraulics Laboratory
P. O. Box 631, Vicksburg, Miss. 39180

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
(12) 267p.

11. CONTROLLING OFFICE NAME AND ADDRESS
U. S. Army Engineer District, New York
26 Federal Plaza
New York, N. Y. 10007

12. REPORT DATE
(11) Sep[redacted]76

13. NUMBER OF PAGES
264

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Hurricane barriers
Hydraulic models
Jamaica Bay, New York
Surges

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

An existing comprehensive physical model that correctly reproduced tides, tidal currents, hurricane surges, and salinity distribution throughout the New York Harbor area and especially the Jamaica Bay complex was used to determine the effects of 13 different hurricane surge barrier plans on the hydraulic environment of Jamaica Bay. The study included tests in the model to determine: (a) the size of the ungated navigation opening

(Continued)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

038 150

20. ABSTRACT (Continued).

that will provide the suppression required inside Jamaica Bay during periods of hurricanes and northeasterly storms; (b) the maximum current velocities in and near the navigation opening that will be experienced by navigation during normal tidal conditions; (c) the effects of the hurricane surge protection structure on tides, tidal currents, salinities, and pollution dispersion patterns within the bay for normal tide conditions; and (d) the minimum area of gated tidal passages required to maintain existing conditions in the bay with respect to salinities and pollution dispersion. During the course of the study, additional tests were conducted to investigate schemes to enhance circulation within the bay.

Based on the results of the model testing program, the following conclusions were reached:

- a. For the sizes of ungated navigation openings considered in this study, a slow rising hurricane surge with a moderate peak water level (similar to the November 1950 surge) produces higher water levels behind the surge barrier in Jamaica Bay than does the Standard Project Design surge, which has a considerably higher peak water level but a much faster period of rise.
- b. A relationship was developed for the cross-sectional area of navigation opening required to achieve various degrees of suppression of the maximum water-surface level (to heights from 5.0 to 6.6 ft) in Jamaica Bay for the November 1950 hurricane surge without astronomical tides.
- c. The maximum velocities for mean tide condition near the navigation opening that can be expected to be experienced by boat traffic vary directly with the total cross-sectional area of the navigation opening and tidal openings.
- d. Barrier plans B, C-1, C-2, and C-3 would have the least effect on the hydraulics of the Jamaica Bay area. Tide phases would be shifted slightly. The magnitudes and locations where current velocities are the greatest in the throat of Rockaway Inlet are increased and shifted, respectively.
- e. Dye dispersion (simulating pollution dispersion) with plan C-1 with a conservative dye source seaward of the barrier indicated that average dye concentrations will be increased slightly in most areas in Jamaica Bay. For the conservative dye source within Jamaica Bay, average dye concentrations will be increased within the bay but will be reduced in areas outside of the bay.
- f. Barrier plan 3 would require the smallest area of gated tidal passages to maintain existing conditions with respect to salinities and pollution dispersion. During the testing program, however, it became evident that velocities in Rockaway Inlet with respect to safe navigation were a more stringent criterion and that barrier plan C-1 would satisfy both the pollution dispersion and safe navigation criteria.
- g. Tests conducted to develop an operative scheme of gate operation to improve circulation in Jamaica Bay indicated that improved conditions could be obtained; however, very adverse navigation conditions also occurred consisting of definite crosscurrents and areas of relatively high velocities.
- h. Tests conducted with various levees, submerged sills, and/or dredging within Jamaica Bay did not result in significant improvements in the flushing of Jamaica Bay.

THE CONTENTS OF THIS REPORT ARE NOT TO BE USED FOR ADVERTISING, PUBLICATION, OR PROMOTIONAL PURPOSES. CITATION OF TRADE NAMES DOES NOT CONSTITUTE AN OFFICIAL ENDORSEMENT OR APPROVAL OF THE USE OF SUCH COMMERCIAL PRODUCTS.

PREFACE

The studies reported herein were requested by the U. S. Army Engineer District, New York (NYD), in a letter dated 24 February 1967, to the Director, U. S. Army Engineer Waterways Experiment Station (WES); approval to conduct the studies was made by the Office, Chief of Engineers, on 7 March 1967.

The studies were conducted in the Hydraulics Laboratory of WES during the period March 1967 to July 1975 under the direction of Mr. H. B. Simmons, Chief of the Hydraulics Laboratory. Messrs. R. A. Sager, Chief of the Estuaries Division, and W. H. Bobb (now retired), Chief of the Interior Channel Branch, directed the physical model study, for which Messrs. T. C. Hill (formerly of WES) and R. F. Athow, Jr., were the Project Engineers. This report was prepared by Mr. Athow. Much of the material contained in this report was taken from preliminary reports prepared by Messrs. Hill and Athow. Mr. Carl Huval of the Mathematical Hydraulics Division provided coordination between the physical model program conducted at WES and a mathematical modeling effort conducted by the Rand Corporation.

Engineers of the NYD responsible for the planning and coordination of the studies included Messrs. F. L. Panuzio and Jesse Rosen. District Engineer during the preparation of this report was COL T. C. Hunter, Jr., CE.

Directors of WES during the course of this investigation and the preparation and publication of this report were COL L. A. Brown, CE, BG E. D. Peixotto, CE, COL G. H. Hilt, CE, and COL J. L. Cannon, CE. Technical Directors were Messrs. J. B. Tiffany and F. R. Brown.

ACCESSION for
NTIS White Section ☑
DDC Buff Section ☐
UNANNOUNCED ☐
JUSTIFICATION
BY
AVAILABILITY CODES
A

OCT 12 1976
D

CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
inches	25.4	millimetres
feet	0.3048	metres
square feet	0.09290304	square metres
square miles (U. S. statute)	2.589988	square kilometres
gallons (U. S. liquid)	3.785412	cubic decimetres
cubic feet per second	0.02831685	cubic metres per second
gallons per day	4.381264×10^{-8}	cubic metres per second
feet per second	0.3048	metres per second
knots (international)	0.5144444	metres per second
feet per second per second	0.3048	metres per second per second

EFFECTS OF HURRICANE SURGE BARRIER ON HYDRAULIC ENVIRONMENT, JAMAICA BAY, NEW YORK

Hydraulic Model Investigation

PART I: INTRODUCTION

The Prototype

1. Jamaica Bay is a sea-level bay at the southwestern end of Long Island in New York State (Figure 1, and Plates 1 and 2). The bay is bordered by Brooklyn on the west and Kennedy International Airport on the northeast. The roughly 20 square miles* of bay is separated from the Atlantic Ocean by Rockaway Beach spit. Shallow, marshy areas constitute the majority of the bay, with a few dredged channels (Island Channel and Beach Channel) and several tidal channels making up the remaining area.

2. The drainage into Jamaica Bay is from about 100 square miles of rainfall-runoff area and from sewage outfalls of a population of 1,500,000. The freshwater contribution has no appreciable effect on the hydraulics of the bay. The primary factors influencing the hydraulics of the bay are the tides and tidal currents of the entire New York Harbor estuary and the local wind-driven circulation. Density gradient effects are of limited importance, as the bay can be considered well mixed.

The Problem

3. The area surrounding Jamaica Bay is highly developed, both commercially and privately. Severe flooding of this area sometimes occurs during tropical hurricanes and northeasterly storms, when water-surface elevations in the bay are raised 5 to 10 ft above normal.

---

* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 4.

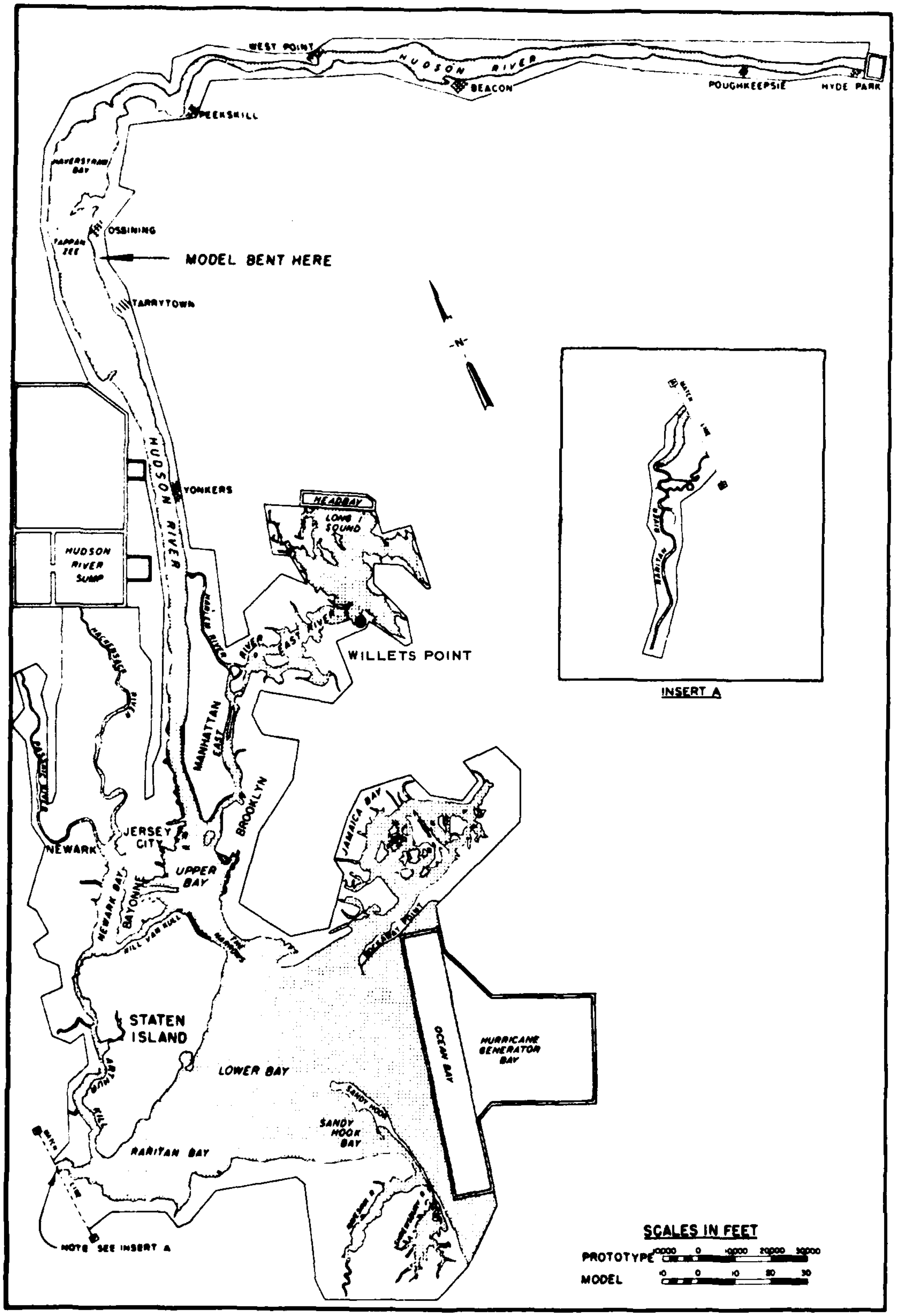


Figure 1. New York Harbor model limits

This flooding has resulted in extensive property damage and associated losses over the years.

4. A proposed solution to the flooding problem in Jamaica Bay is the construction of a raised beach backed by floodwalls along Rockaway Beach and a hurricane surge barrier in Rockaway Inlet. This study addresses the barrier part of the comprehensive plan to limit flooding in the bay.

Purposes of the Model Study

5. At the outset, the model study was conducted to determine: (a) the size of the ungated navigation opening that will provide the suppression required inside Jamaica Bay during periods of hurricanes and northeasterly storms; (b) the maximum current velocities in and near the navigation opening that will be experienced by navigation during normal tidal conditions; (c) the effects of the hurricane protection structure on tides, tidal currents, salinities, and pollution dispersion patterns within the bay for normal tide conditions; and (d) the minimum area of gated tidal passages required to maintain existing conditions in the bay with respect to salinities and pollution dispersion. During the course of the study, additional tests were conducted to investigate schemes to enhance circulation within the bay.

PART II: THE COMPREHENSIVE MODEL

Description

6. The New York Harbor model reproduced the tidal portions of all significant tributaries to the harbor with the exception of the Hudson River which was reproduced only as far upriver as Hyde Park, New York. The tributaries were originally molded in the model to conform to the latest available hydrographic surveys at the time of model construction (1957). In subsequent years, updating of various portions of the model was necessary with the result that the dates of surveys for model construction varied throughout the model. The model was of the fixed-bed type, molded entirely in concrete, and was constructed to linear scale ratios, model to prototype, of 1:1000 horizontally and 1:100 vertically. These scale ratios fixed the following relations: slope 10:1; velocity 1:10; time 1:100; discharge 1:1,000,000; and volume 1:100,000,000. The salinity scale ratio required for this investigation was 1:1. One prototype tidal cycle of 12 hr and 25 min was reproduced in the model in 7.45 min. A detailed discussion of the New York Harbor model and the model verification is presented in Reference 1. The model limits are shown in Figure 1.

Appurtenances

7. The model was equipped with the necessary appurtenances to reproduce and measure all pertinent phenomena. The appurtenances included primary and secondary tide generators, freshwater inflow weirs, skimming weirs, salinity meters, chemical titration equipment, current velocity meters, point gage and water level transmitters, fluorometers for dye concentration determination, and hurricane surge generator.

Tide generators

8. Tides are reproduced in typical estuarine models by controlling pumped inflows into the model from an ocean supply sump, coupled with programmed gravity return flows to the sump. Figure 2 is a

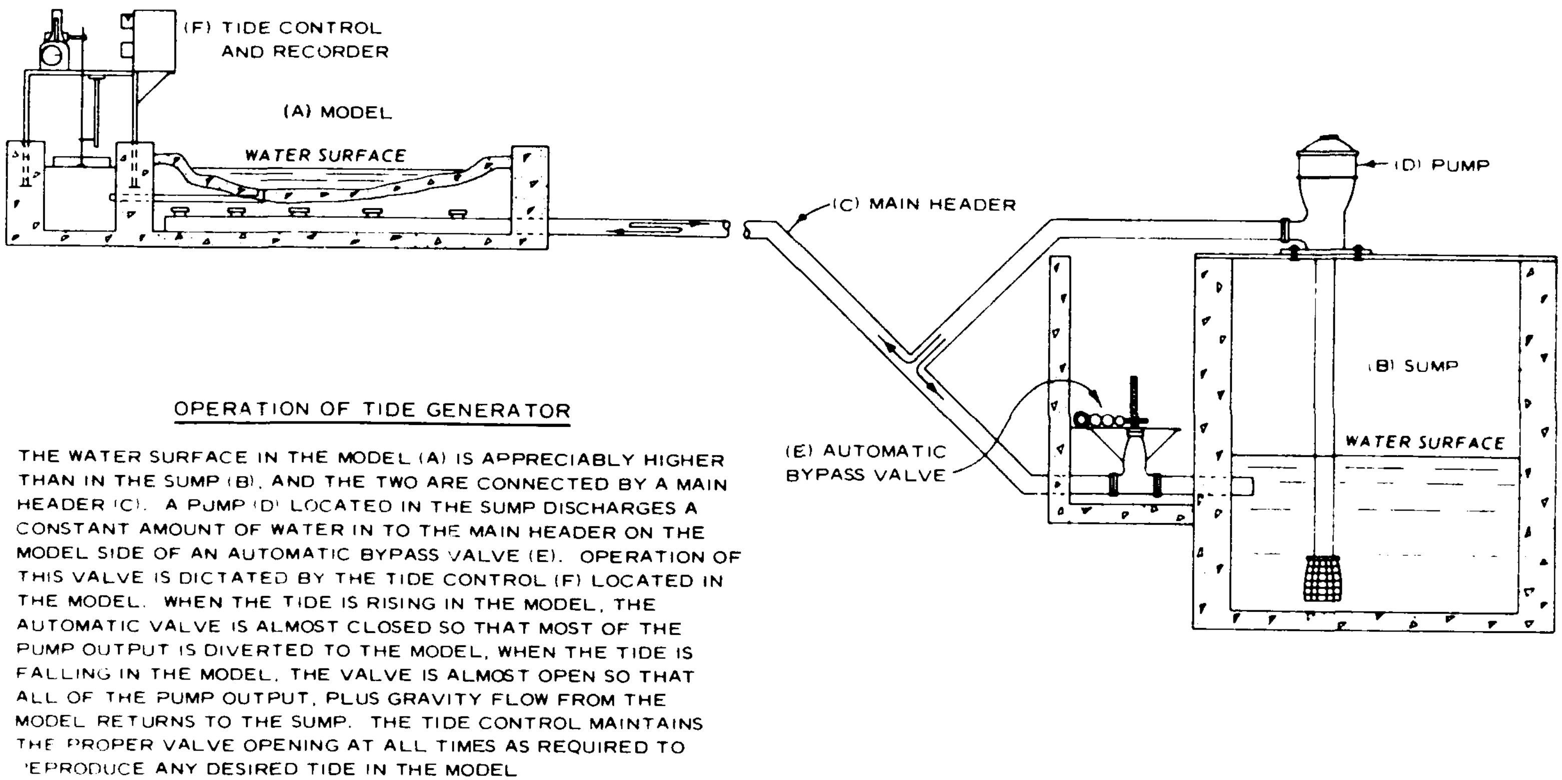


Figure 2. Schematic diagram of a typical tide generating system

simplified schematic diagram of a typical tide generating system. The New York Harbor model differed from the typical tide generating system, in that it required three separate tide generators: (a) a primary tide generator to reproduce the Atlantic Ocean tides by controlling flow to and from the ocean headbay; (b) a second primary tide generator at the cutoff point in Long Island Sound to maintain flow to and from the model at that location for the accurate reproduction of tides at Willets Point; and (c) a secondary tidal apparatus necessary to correctly reproduce tidal flow conditions in the Hudson River at Hyde Park, New York. The Atlantic Ocean inflow was pumped at a constant rate, and the gravity return flow was regulated with a programmed valve to cause a correct reproduction of the prototype tides, basically as described in Figure 2. However, the tide generating system for Long Island Sound was operated so that the inflow varied with a programmed valve and the gravity outflow remained constant. The Hyde Park apparatus removed the flood tidal prism of the Hudson at the model limit at the proper rate, stored the tidal flow for the proper time interval, and returned it to the system at the proper rate during the ebb tide. The Atlantic Ocean and Long Island Sound tide generators were each equipped with a tide recorder, which plotted continuous records of the model reproduction and the desired prototype tide curve for comparison. Also installed on the tide generators were model clocks which indicated time in prototype hours, referred to the moon's transit of the 74th meridian, and recorded the test duration in tidal cycles.

Inflow weirs

9. The Hudson and Raritan River inflow systems were each equipped with inflow weirs and constant head tanks to control the introduction of the respective freshwater inflows required at Hyde Park, New York, and at New Brunswick, New Jersey.

Skimming weirs

10. Tidal reproduction in the model was completely automatic and was designed to operate continuously with a constant volume of water in the model/sump system. Maintaining a constant volume of water required that water be removed and wasted from the downstream end of the

model through a skimming weir at a rate equal to the total freshwater inflow of all the tributaries. A skimming weir was used in order to collect water from the surface where salinities were at a minimum (thus, the minimum amount of salt was wasted).

Salinity meters and
chemical titration equipment

11. Salinity concentrations of water samples taken from the model were determined by the use of conductivity cells especially built and calibrated for this purpose or by chemical titration with silver nitrate. The cells were considered to be accurate to within ±2 percent of full range, which amounts to about ±0.2 parts per thousand (ppt) in the lower ranges of salinity and ±0.5 ppt in the higher ranges of salinity. The salinity meter assembly is shown in Figure 3. In all cases where a high degree of accuracy was required, such as source salinities, chemical titration was used. The chemical titration equipment consisted of a graduated burette for measuring silver nitrate volumes, a selected

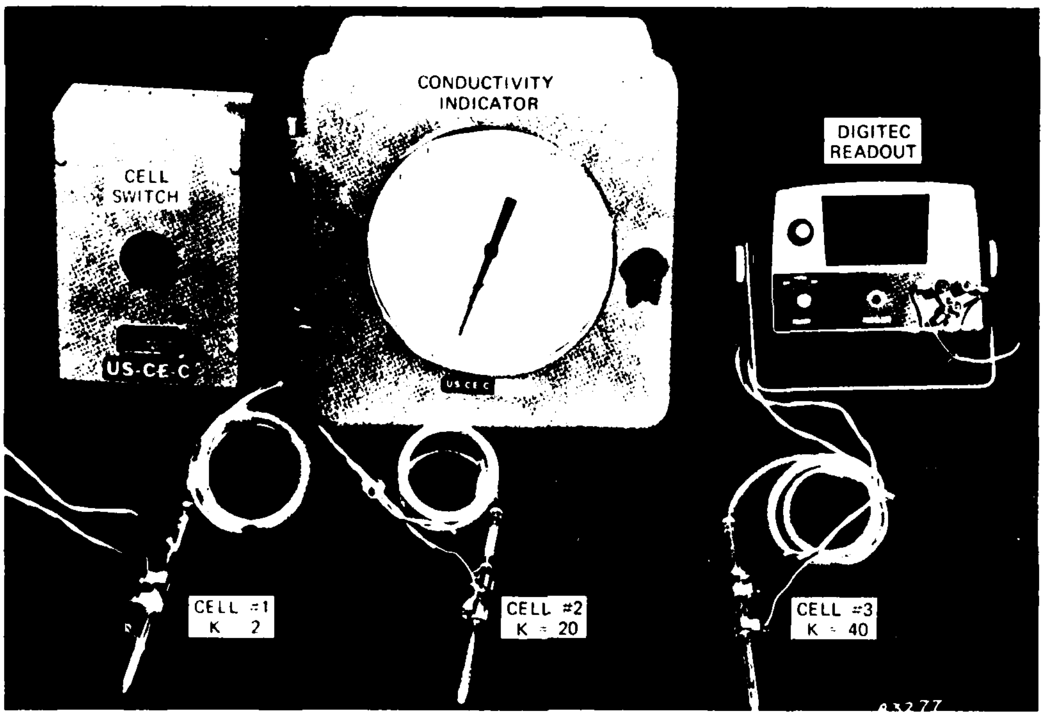


Figure 3. Salinity meter

group of pipettes for measuring the volume of samples used, sample jars in which to perform the titration, a supply of silver nitrate, and potassium chromate for use as an end-point indicator in the titration process.

Current velocity meters

12. Current velocity measurements were made in the model with miniature Price-type current meters (Figure 4). The center line of the five cups on the meter was about 0.05 ft above the bottom of the meter frame; therefore, bottom velocities in the model were measured about 5.0 ft (prototype) above the bottom. Model surface velocities were measured about 3.0 ft (prototype) below the surface. The overall width of the meter was about 0.1 ft in the model, representing a horizontal width of about 100 ft in the prototype. Therefore, the distortion of area (model to prototype) resulted in comparing model velocities averaged over a much larger area than those of the prototype point observations.

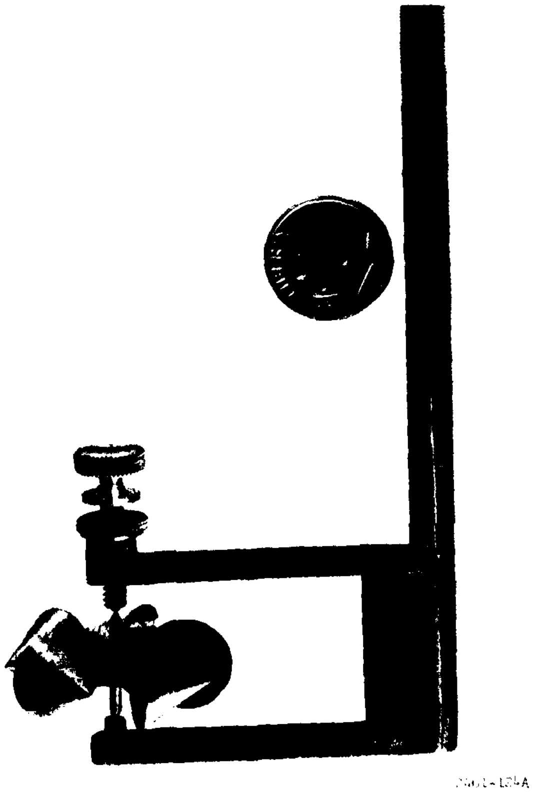


Figure 4. Current meter

The same was true for the vertical area since the height of the cups on the meter was equivalent to about 4.0 ft prototype. Velocities were obtained by counting the number of revolutions of the meter wheel in a 10-sec interval (about 17 min in the prototype). The meters were calibrated frequently to ensure accurate operation and were capable of measuring actual velocities as low as about 0.03 fps (0.3 fps prototype). Accuracy of the meters was considered to be ±0.3 fps (prototype).

Point gages and
water level transmitters

13. Permanently mounted point gages were installed on the model at locations corresponding to the prototype recording tide gage locations at which verification tide data were collected, plus additional locations considered necessary for test purposes. These gages, graduated to 0.001 ft (0.1 ft prototype), measured tidal elevations throughout the model. When necessary, portable gages were used to obtain more detailed tidal data in specific reaches of the model. Capacitance-type water level transmitters also were employed to collect instantaneous water elevations for periods of 15 to 20 tidal cycles. Accuracy of the capacitance transmitters was ±0.001 ft (±0.1 ft prototype).

Fluorometer

14. The concentrations of fluorescent dyes introduced into the model to determine dispersion patterns of the Lower Bay waters were measured with a Turner fluorometer (Figure 5). The required size of the samples was 5-cc, and the meters were calibrated to read values between 1 to 10,000 parts per billion (ppb). Accuracy of the fluorometer was about ±3 percent for the range of concentrations measured.

Hurricane surge generator

15. In order to simulate the surge in water elevations associated with hurricanes and other severe storms, an embayment was built adjacent to the Atlantic Ocean headbay (Figure 1). Into this 30- by 30-ft bay a box structure was lowered at a programmed rate, displacing water into the model area at rates which gave the correct elevation versus time history at the control gage (Fort Hamilton).

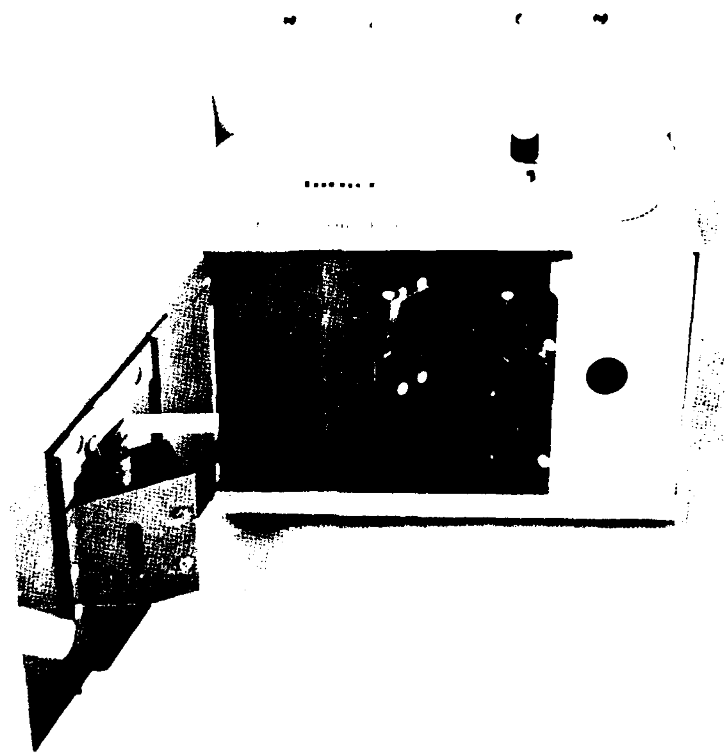


Figure 5. Turner fluorometer

PART III: MODEL VERIFICATION

16. Two separate hydraulic verifications of the Jamaica Bay model area were made. The first major effort was to duplicate in the model, as closely as possible, prototype data taken during June 1967. The second effort was to tune the model phase lags to agree with those found in nature during October 1970. These two attempts are discussed separately in the followings sections.

Comprehensive Verification to June 1967 Prototype Data

17. Verification of the Jamaica Bay portion of the model consisted of three phases: (a) hydraulic verification, which involved adjustment of the model until tidal elevations and current velocities were in proper agreement with the prototype; (b) salinity verification, which ensured that salinity phenomena in the model corresponded to those in the prototype for similar conditions of tides, ocean source salinity, and upland discharge; and (c) hurricane surge verification, which proved that the model accurately reproduced elevations of observed hurricane surges. In addition to the natural bottom roughness provided by the concrete used to construct the model, copper roughness elements 3/4 in. wide were placed in a random manner in the deeper areas of the model and bent up or down as required to obtain the proper reproduction of tidal elevations and phases, current velocities, and salinities. Also, a light coat of stucco was applied to the model areas where tidal marshes existed to simulate the required degree of hydraulic roughness in these shallow areas. Prototype tidal data from six recording tidal gages (Figure 6) were used for the initial adjustment of the model roughness. These prototype gages recorded continuously during the period 12-13 June 1967 when prototype current velocities and salinities were also measured.

18. Adjustment of the Jamaica Bay tidal elevations and phases was accomplished by generating a mean tide at the Sandy Hook, New Jersey, U. S. Coast and Geodetic Survey (USC&GC) ocean control tide station, with a range of 4.7 ft, and then adjusting the copper strip roughness elements

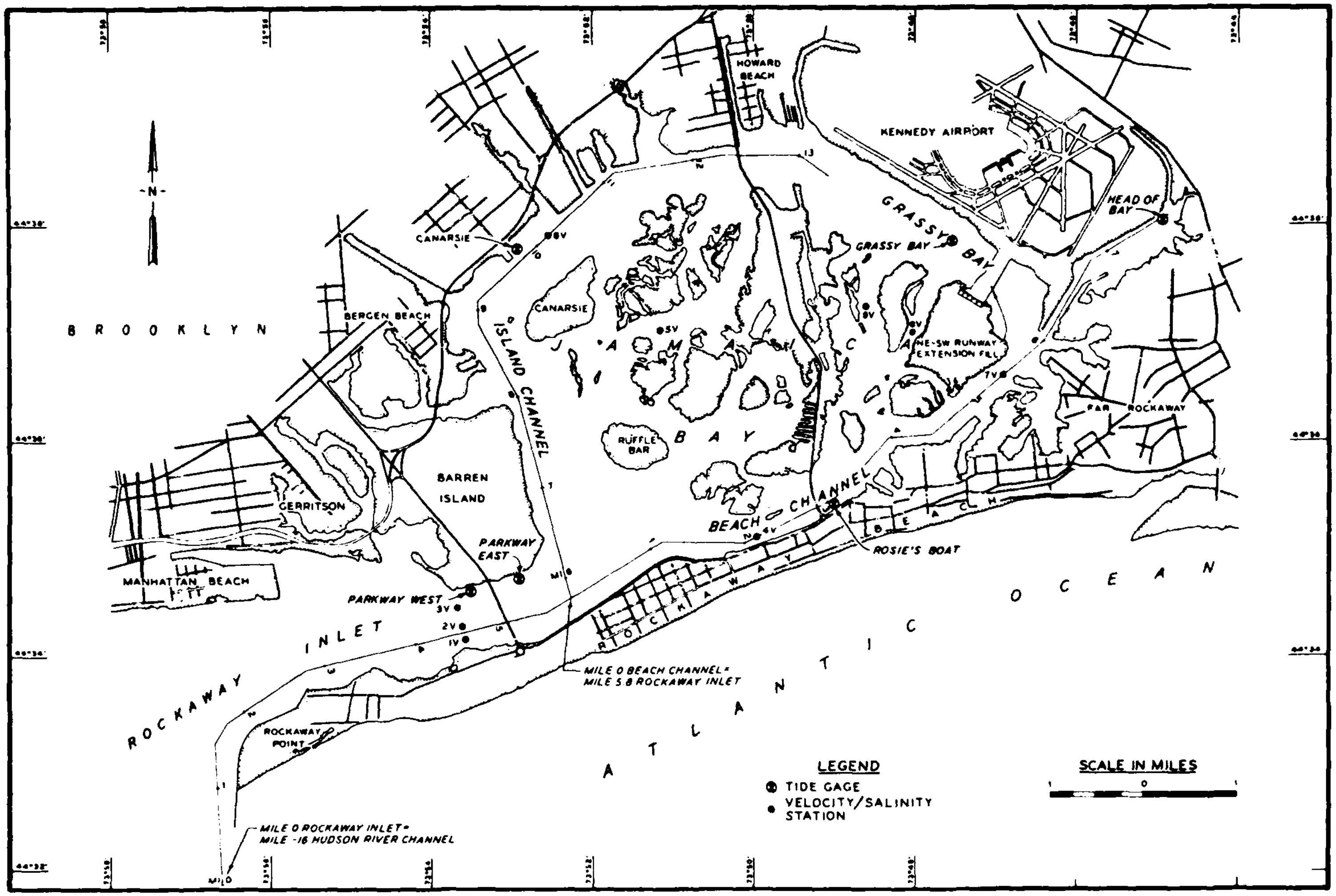


Figure 6. Location map for verification tests (1967)

in Jamaica Bay and Rockaway Inlet until the tides were in close agreement with the prototype data throughout the bay. Further minor refinements were made to the roughness elements during adjustment and verification of current velocities.

19. The accuracy with which the model reproduced prototype tides is illustrated by the comparative curves in Plates 3-6. There was reasonably good agreement between the model and prototype for the times of occurrence of both high and low waters (differences of 15-30 min were noted at some stations). The tide ranges inside the bay in the model were slightly greater (about 0.4 ft) than for the prototype. The agreement between model and prototype was considered to be satisfactory.

20. The final (minor) adjustment of model roughness resulted in an accurate reproduction of the magnitude and distribution of prototype velocities, in both the vertical and horizontal, for the Rockaway Inlet channel and throughout the major channels in Jamaica Bay. Prototype current velocities were available for sta 1 V-9 V, located as shown in Figure 6. The accuracy with which the model reproduced the prototype velocities is illustrated by comparative curves in Plates 7-15. An acceptable agreement was obtained at all stations with the exception of the middepth and bottom at sta 4 V. The bottom of the channel at this station was very deep and narrow. The model velocity meter was too wide to be lowered to the required depths for the middepth and bottom velocities measurements, resulting in higher values in the model than were observed in the prototype. The velocities were observed at surface depths only for sta 7 V-9 V and at middepth only for sta 5 V due to the shallow depths of the channels at these locations. The agreement between model and prototype velocities was considered to be satisfactory.

21. Salinity verification of the model was conducted to ensure that the overall vertical mixing of salinity in the model was in good agreement with the density gradient observed in the prototype. Salinity measurements were made in the prototype during the same periods of time that tides and velocities were measured. The prototype data indicated no appreciable salinity gradient existed in Jamaica Bay between the surface and bottom depths; however, the bottom salinity values were

generally slightly higher than surface values. Salinities increased from a minimum value at periods of low-water slack to a maximum value at periods of high-water slack. The model source salinity (ocean supply sump) was maintained at a constant 30,000 parts per million (ppm) throughout salinity verification and all subsequent tests. The major freshwater inflows were from the Hudson River at Hyde Park and Raritan River at the head of tide and were maintained at 12,000 cfs and 1,700 cfs, respectively. Additional continuous freshwater inflows were introduced into Jamaica Bay at the nine outfall locations shown in Plate 1 and at the rates of millions of gallons per day (mgd) listed in Table 1. The model was operated for a period of no less than 30 tidal cycles (equivalent to 15 days) to ensure that salinities throughout the model had become stable after which time, hourly surface and bottom water samples were taken at sta 1 V-7 V (Figure 6). Model salinities were in very good agreement with corresponding prototype data, reproducing all major trends observed in the prototype. The agreement of the salinity regime in the model, as compared with the prototype, is considered excellent and is shown by comparative curves in Plates 16-22. No additional adjustment of the model roughness was required to achieve a satisfactory salinity verification.

22. The final phase of model verification was the adjustment of the hurricane surge generator to reproduce known or projected hurricane surge elevations throughout the problem area. The two surges used for verification were: (a) a surge which actually occurred during the period 24-26 November 1950, and (b) the Standard Project Design surge with the eye of the hurricane moving at a speed of 40 knots. Water level time histories used to verify the November 1950 surge with the predicted astronomical tide analytically removed from the prototype data were taken from Reference 2. For the Standard Project Design hurricane, both with and without the predicted astronomical tide, and for the November 1950 surge including the actual astronomical tide, water levels were taken from data provided by the New York District.

23. The hurricane surge generator was programmed by trial and error to produce the surge that occurred at Fort Hamilton for the November 1950 hurricane minus the predicted astronomical tide. Thus,

the model tide generator was not operated during this surge test. After this was accomplished, elevations were observed at seven other stations (Figure 7) located throughout the Lower New York Harbor and Bay system. Model reproduction of the surge was in good agreement with the prototype at all stations except Perth Amboy and Lawrence Point. These stations were located far from the area of interest, and attempts to obtain a more satisfactory agreement between the model and prototype at Perth Amboy and Lawrence Point were determined to be not necessary. Results of the model verification for the November 1950 surge with the portion of the tide attributed to the predicted astronomical tide removed can be seen in Plates 23-26. No additional adjustment of the model roughness was required.

24. The surge generator was then programmed in turn to reproduce the Standard Project Design hurricane at Fort Hamilton both with and without the mean astronomical tide. Results of these two tests can be seen in Plate 27. The final verification test involved the November 1950 hurricane including the actual tide at Fort Hamiltom; the results of this adjustment are shown in Plate 28. From a model operations standpoint it was more convenient to generate the combined hurricane surge and astronomical tide with the surge generator only. Thus, the tide generator was not operated for any of the surge tests, even those which included the astronomical tide. Since these three tests reproduced prototype conditions only at the control station, they were not verification tests in the usual sense. They are included in this part of the report, however, for convenience. Verification of all hurricane surges tested was considered to be excellent.

25. The results of hydraulic and salinity verification of the model indicated very satisfactory agreement between model and prototype phenomena. The model was considered to be sufficiently similar to its prototype to be confidently used in quantitative studies of the effects of changes in prototype conditions.

<u>Tidal History Verification to October 1970 Prototype Data</u>

26. Extensive discussions of the quality of the June 1967

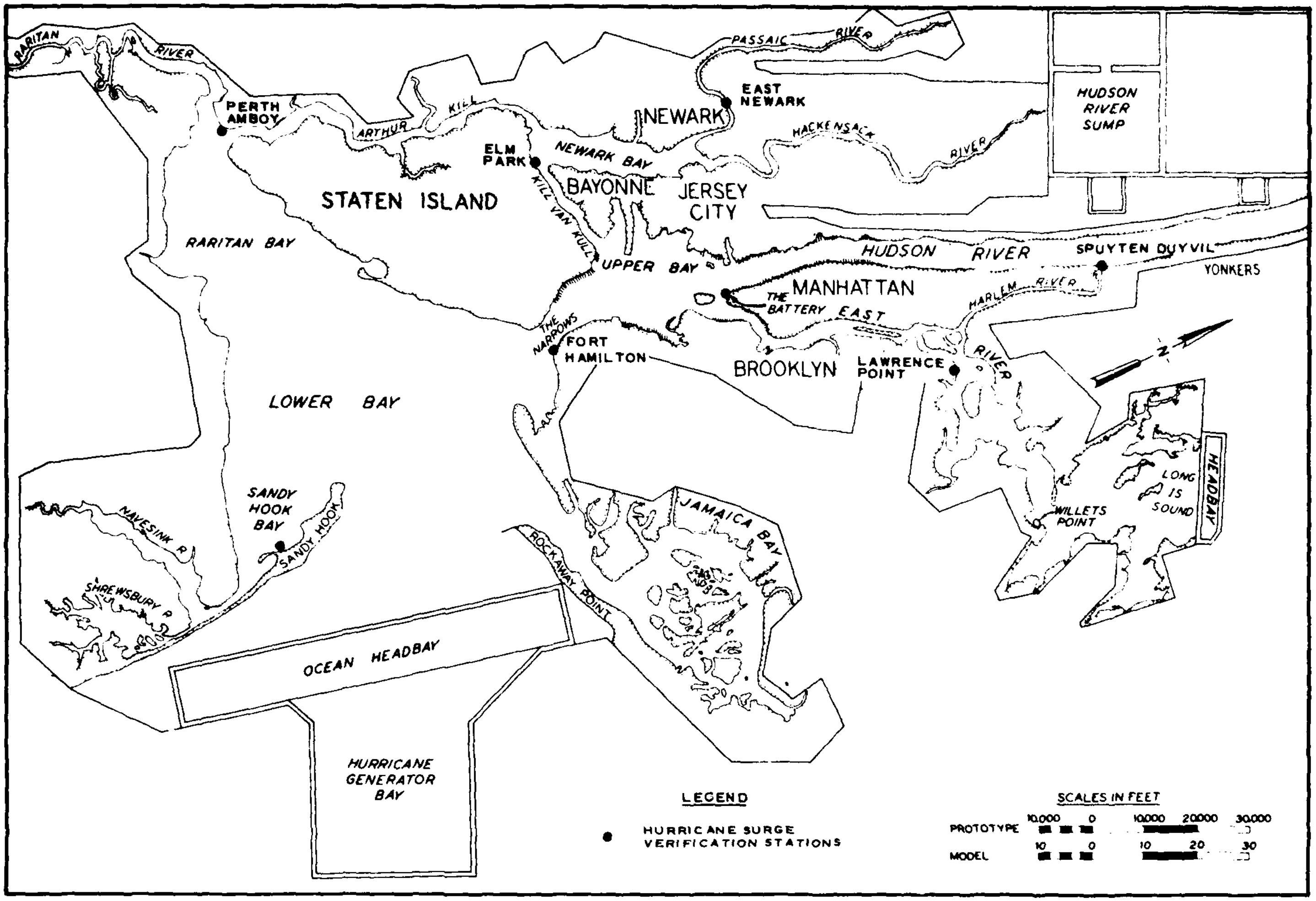


Figure 7. Location map for hurricane surge verification tests (1967)

prototype data lead to another prototype data survey in October of 1970. The analysis made by the U. S. Army Engineer Waterways Experiment Station (WES) of the October 1970 prototype data lead to the conclusion that the two prototype data sets (i.e., June 1967 and October 1970) were not dissimilar enough to warrant further adjustments to the physical model. However, at this point it was decided that, in order for the results from both the physical model and an existing mathematical model* to be compared most readily, a further adjustment of the physical model tidal phasing within Jamaica Bay must be accomplished.

27. The analysis procedure developed to compare prototype tidal energy and model tidal energy is reported in Reference 4. The actual physical model readjustment was completed in three steps as described below.

28. The first step was to place automatic water level transmitters at the same locations as those used in October 1970 in the prototype. Figure 8 shows the locations of the five stations used in this verification. The water level sensors measured the water elevations continuously, and each sensor was sampled electronically at intervals of 7.5 min prototype (4.5 sec model time). A magnetic tape of water elevations versus time for a period of at least 17 consecutive tidal cycles was prepared and shipped to the Rand Corporation for spectral analysis. This first step was referred to as the March 1974 model experiment.

29. The analysis of the March 1974 experiment showed that, for the principal lunar tidal component (M_2), the model tidal amplitudes agreed well with the prototype, but the phase lags between stations differed by 3 to 4 min from those found in the prototype. The worst agreement was found in the relatively isolated reach extending from Rosie's Boat to Head of Bay where a difference of 246 sec was found. For step two of the tidal adjustment, it was decided to add additional strip roughness to the channel areas between Rosie's Boat and Head of Bay and to monitor tides for another 17 consecutive tidal cycles for

* A mathematical model had been previously developed by Rand Corporation under New York City sponsorship.[3]

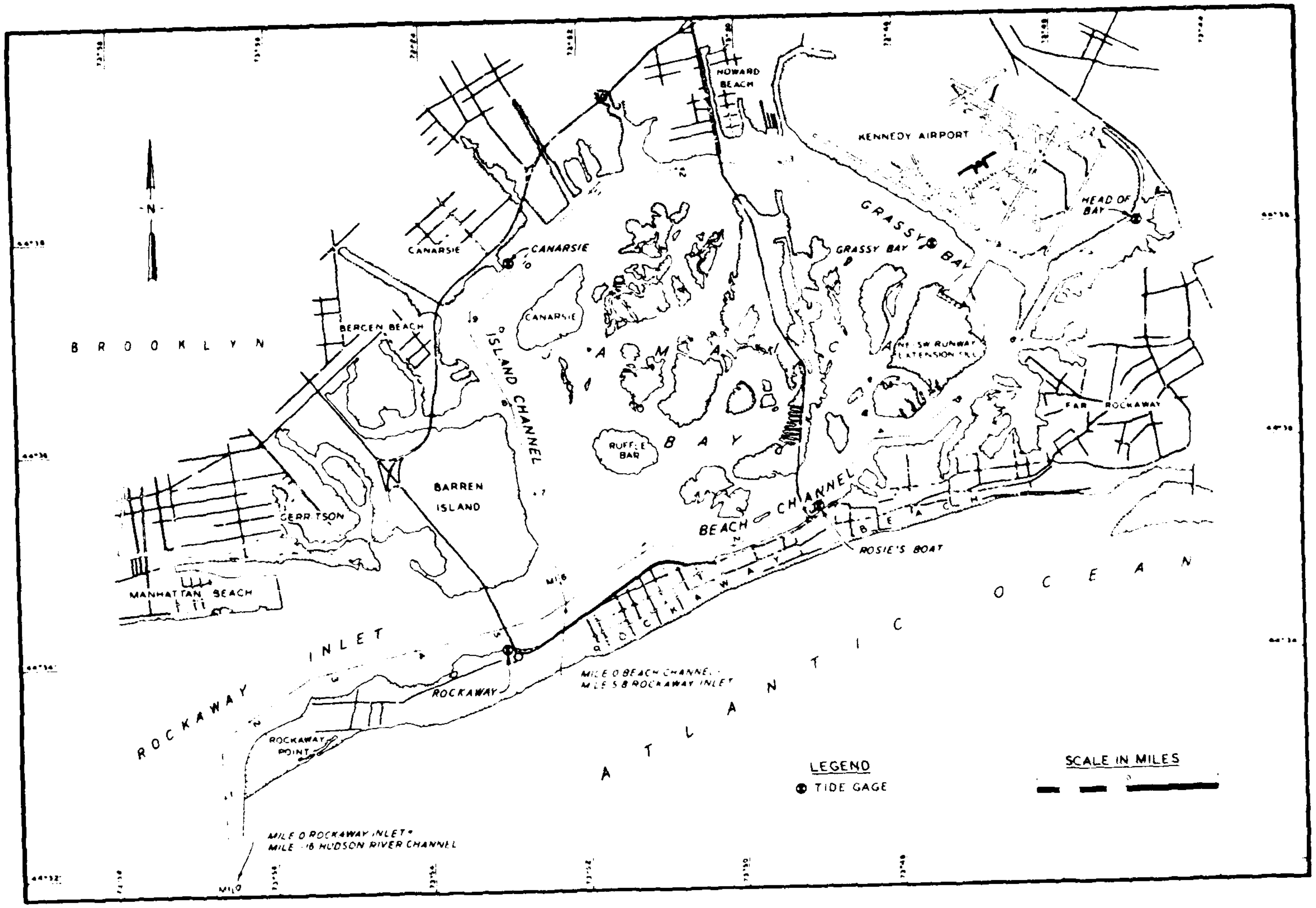


Figure 8. Location map for tidal verification tests (1970)

analysis. This portion of the program was referred to as the April 1974 model experiment.

30. The amount of roughness needed was estimated using an analytical procedure developed at WES.[5] In this reference, a relation is given for the number of roughness elements required per square foot of model as a function of the prototype depth. From this relation, it was decided that 50 additional roughness elements would be required to retard the flow sufficiently.

31. An analysis of the April 1974 experiment revealed that the error in model phase lag between Rosie's Boat and Head of Bay had been reduced from 246 sec to 69 sec. On the basis of this result, the third and final step in the tidal phasing verification was undertaken.

32. Step three involved the same procedure as step two, except that all the major channel areas in the bay were investigated, and roughness elements were added as determined from the analytical procedure. It should be noted that the roughness element computation was concerned only with those areas within the channels, and not with any of the areas in the extensive tidal flats. The final tidal phase verification run is referred to as the 25 June 1974 experiment. Two previous tests had been run earlier in June, but both were aborted by malfunctioning water level transmitters at critical locations (i.e., Grassy Bay and Head of Bay). The analysis of the 25 June 1974 experiment showed that the error in model phase lags between most stations had been reduced to 26 sec or less. Figure 9 (taken from Reference 4) illustrates the three steps of the tidal phase adjustment program.

33. It was concluded from the results of the 25 June 1974 experiment that the phase lags and amplification of the semidiurnal tide (M_2) in the physical model agreed well with those found during October 1970 in the prototype. The physical model was judged in good agreement with the mathematical model, and so further joint testing proceeded. Tests of the 40-gate barrier (plan C-1) and the 35-gate barrier (plan C-3) were conducted in both the physical model and the mathematical model. No comparisons of the results of these tests were made between the two models, however. The final results of the mathematical modeling effort are given in Reference 6.

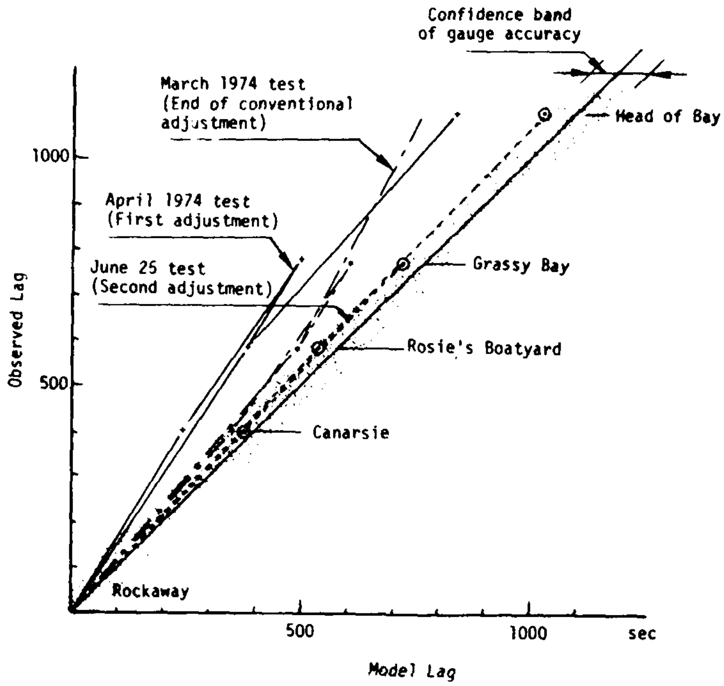


Figure 9. Observed lag versus model lag of the M_2 tide component taken from Rockaway for the different experiments (Reference 4)

Discussion

34. The two hydraulic verifications as described previously were undertaken from different approaches. It is of interest, therefore, to assess a comparison of the two procedures in their effects on the Jamaica Bay model system.

35. Plates 3-6 are the verification plots of the tidal sets of interest: prototype 1967, base 1967, and base 1974. The base 1974 curves actually represent conditions for the same ocean tide in the model as the base 1967 curves; however, the model roughness had been revised as discussed above. It is readily seen that the tidal range generally was decreased by only about 0.1 ft and that the tidal phasing was somewhat improved (the small change in phase lags is difficult to discern at the scale of these plots).

36. A comparison of current velocities taken during the base 1967 tests and the base 1974 tests (Plates 7-15) showed marked decreases in the magnitudes of the flood and ebb velocities both in the entrance to the bay (sta 1 V, 2 V, and 3 V) and those stations scattered throughout the bay (see Plate 1 for station locations). In most instances, the comparison between model and prototype velocities was not adversely affected. No effort was expended to reverify the current velocities to either the 1967 or 1970 prototype data; the tidal phase adjustment was assumed to be the most critical factor affecting circulation within the bay for the physical model. Local wind fields and pressure gradients are certainly contributing factors in water circulation in the prototype and are not simulated in the physical model.

37. Plates 16-22, which show comparisons of the salinity regime in Jamaica Bay between the 1967 and 1974 base tests, are included to show the minimal effects the tidal phase adjustment had on the salinities in an already well-mixed bay.

PART IV: MODEL TESTS AND RESULTS

38. During the course of this study a total of thirteen plans were tested. These tests are grouped in five phases and will be discussed separately. A summary of the dimensions of the gates and navigation openings for the various plans is presented in Table 2.

39. Since the 1974 tide-phase verification was not accomplished until late in the testing program, many of the barrier tests were completed with the original model roughness arrangement and compared with the 1967 base test. All plates and tables comparing plan and base test results indicate the appropriate base test (i.e., 1967 or 1974).

Procedure for Tests

40. In testing any barrier design that incorporated various combinations of gated and ungated openings, the basic procedures for the model tests were as follows:

a. The barrier was modeled to an undistorted scale of 1:100, and tests were made in the undistorted-scale model under steady-state conditions of both flood and ebb flows for head differentials up to and beyond the maximum to be expected in later tests.

b. The discharge through the structure was determined as a function of both head differential and water-surface elevation.

c. Data described in b were used as the basis for calibrating a distorted-scale model of the barrier for installation in the New York Harbor model.

d. Tests were conducted in the New York Harbor model to determine the effects of the barrier design on tides, tidal currents, salinities, the dispersion and flushing of dyes introduced at the simulated waste outfalls, and hurricane surge elevations in Jamaica Bay.

Figure 10 shows the locations of the different barrier plans within Rockaway Inlet.

Base Tests

41. Once the 1967 verification of the Jamaica Bay portion of the

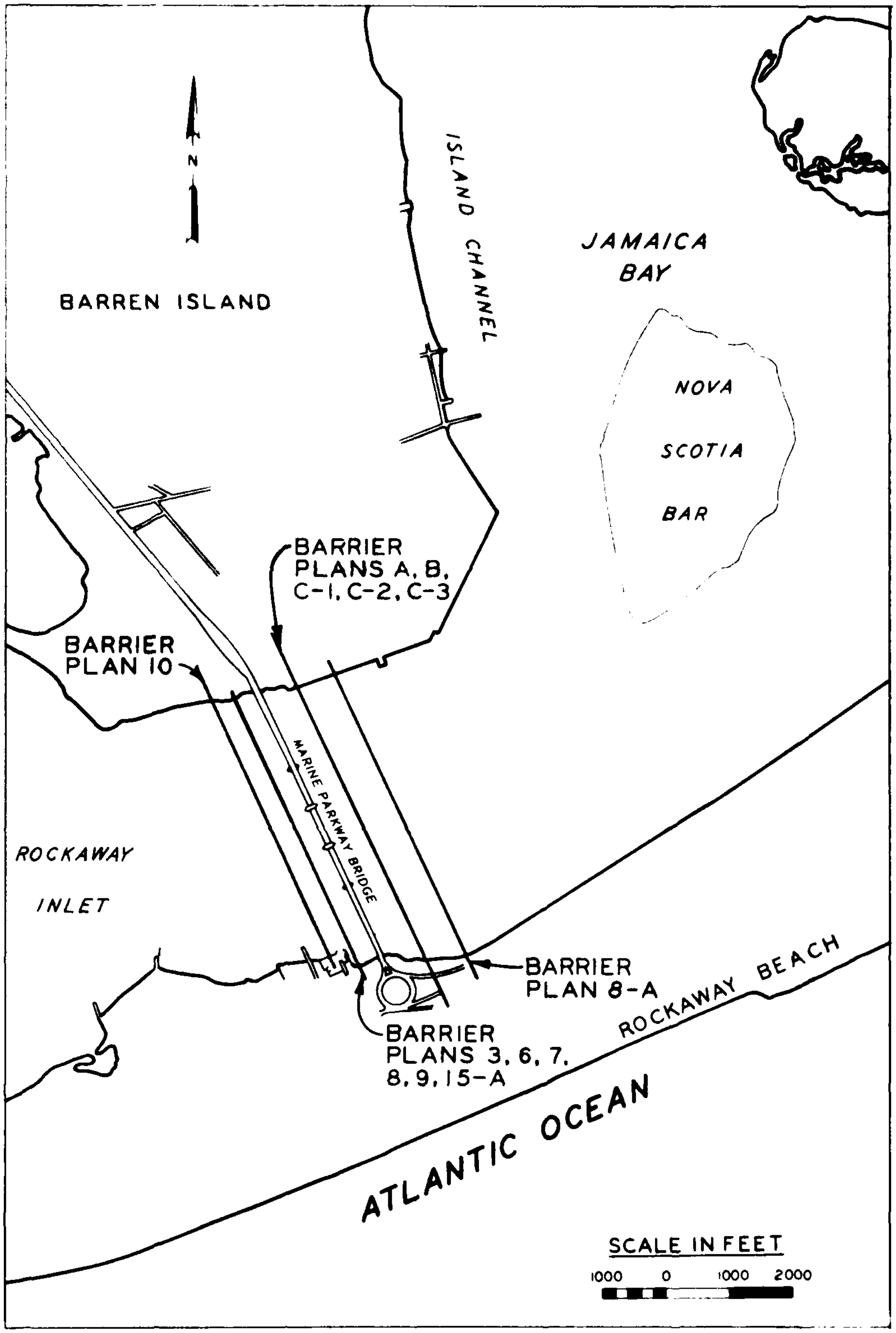


Figure 10. Location of barrier plans within Rockaway Inlet

New York Harbor model was accepted as being sufficiently accurate, a series of base tests, or tests of existing conditions, were made under carefully controlled conditions of tides, freshwater inflow, simulated pollution input, and hurricane surges. The results of these tests were used to evaluate the effectiveness of the various barrier designs tests; therefore, the subsequent tests incorporating barriers were made under the same carefully controlled conditions as were the base tests. It can be stated that differences noted between the test results without and with barriers were attributable to the barrier plans being tested (with proper consideration given to model test repeatability). Except for the Standard Design Project hurricane surge, the results of the base tests are not presented separately in this report; instead, these results are presented along with the results of tests incorporating barriers for ready illustration of the effects of the barriers.

Phase 1: Earliest Barrier Schemes

42. Operating conditions established for base tests in phase 1 consisted of reproducing a mean tide (4.7-ft range at Sandy Hook), median freshwater inflows in the Hudson River (12,000 cfs) and the Raritan River (1,770 cfs), and maintaining an ocean salinity of 30 ppt. For the pollution base test, one fluorescent dye was used to simulate pollution from sources seaward from the barrier location, and a second fluorescent dye was used to simulate pollution from sources landward from the barrier. The initial concentration of dye (100,000 ppb) introduced for each pollution source and the discharge rates at the nine outfalls simulated are shown in Table 1. The dye tests were conducted with continuous injection of dye at each injection location, and the model was operated until dye concentrations reached a quasi-steady-state condition. Dye concentrations were then measured throughout the problem area at five-cycle intervals during tidal cycles 1-100. These early tests were conducted before the model roughness arrangement was revised; therefore, the test results are compared with the 1967 base test.

Plan 3

43. Plan 3 was the first plan subjected to model testing. This plan consisted of a 300-ft-wide ungated navigation opening at natural bottom depth of about -33 ft mean sea level (msl), flanked by two gated sections each consisting of six 75-ft-wide tide gates with sills at -26 ft msl. As explained in test procedures, the plan 3 barrier was first installed in the undistorted-scale model for discharge rating tests, following which a distorted-scale barrier was calibrated for use in the New York Harbor model. With this calibrated structure installed, tests were made in the New York Harbor model to determine the effects of plan 3 on tides, tidal currents, salinities, diffusion and flushing of dye tracers, and suppression of the two hurricane surges used for test purposes.

44. The effects of plan 3 on tidal elevations and phases at 11 tide gages are shown in Plates 29-32 (see Plate 1 for gage location). Tidal ranges throughout Jamaica Bay were not changed significantly by plan 3, but the phasing of the tides was delayed somewhat (20-30 min at high water and less than 15 min at low water) and the elevation of the mean water level was raised slightly (0.1-0.2 ft). The effects of plan 3 on current velocities at 23 stations are shown in Plates 33-55 (see Plate 1 for velocity station locations). Velocities were essentially unchanged west of the barrier in Rockaway Inlet (sta 1 OC and 3 OC). Maximum surface ebb velocities were increased by 0.7 and 1.3 fps at sta 1 V and 2 V, respectively, while maximum surface ebb velocity was reduced by 1.5 fps at sta 3 V, indicating that the barrier changed the distribution of flow to some extent in the vicinity of the structure.

45. At sta 4 V in Beach Channel of Jamaica Bay, maximum bottom flood velocity was reduced by 1.2 fps by the barrier; however, examination of velocities at sta 1 BCH, 4 BCH, and 7 V (further upstream in Beach Channel) indicates no significant change in velocities, so it appears that the changes in velocity at sta 4 V were attributable to a change in flow distribution in the area. Data for sta 8 V and 9 V indicate that plan 3 had no significant effects on the exchange of flow between Island Channel and Beach Channel; however, measurements at

sta 13 ICH indicate that the barrier increased flood velocities at that location, which suggests that an existing slight net flow to the east at this station may have been increased slightly by plan 3. It is emphasized, nevertheless, that the shape of the cross section at sta 13 ICH is not ideal for velocity measurements, and it is possible that the results of measurements at one point in this cross section may be misleading. Measurements at other stations in Island Channel (sta 7 ICH, 9 ICH, and 11 ICH) indicate that velocities were not affected appreciably by plan 3. Maximum velocities at stations located on the center line through the navigation opening were on the order of 5 to 7 fps. West of the barrier sta 14 V and 15 V showed maximum ebb velocities of 4.8 to 6.2 fps and 6.1 to 7.0 fps, respectively. East of the barrier, sta 16 V and sta 17 V showed maximum flood velocities of 6.5 to 6.6 fps and 4.8 to 5.0 fps, respectively.

46. The effects of plan 3 on salinities at 18 stations are shown in Plates 56-73 (see Plate 1 for salinity station locations). At most stations in Jamaica Bay, the effects of the plan on salinities were less than 0.5 ppt. The maximum effects were noted at sta 0 BCH, where both the surface and bottom salinities were reduced about 0.5 to 1.0 ppt. In general, it can be stated that the effects of plan 3 on the salinity regime of Jamaica Bay were negligible.

47. The pollution test of plan 3 was identical to the pollution base test described in paragraph 42, except that the barrier plan was installed in the model. The sources of pollution simulated and the discharge and concentration introduced at each source are listed in Table 1. The locations of each source are shown in Plate 1. The sampling stations employed for these tests are shown in Plates 1 and 2. Surface and bottom samples were obtained periodically at all stations, and the samples were analyzed for concentrations of each dye by means of a Turner fluorometer.

48. The results of the pollution test of plan 3 are summarized in Tables 3 and 4, along with the results of the pollution base test for ready comparison. For the purpose of this report, the region seaward from the barrier was divided into three areas (the approach

channel, Coney Island Beach, and the basins), and Jamaica Bay was divided into four areas (Beach Channel, Island Channel, the tidal flats, and the basins). For the last 30 tidal cycles (tidal cycles 70-100) of the base and plan tests, the results of all sampling performed in each area were averaged, and the average concentrations thus determined are shown in Table 3 for dye sources seaward from the barrier location and in Table 4 for dye sources bayward from the barrier location. It will be noted that, for dye sources seaward from the barrier site, average dye concentrations for plan 3 were reduced from those for the base test in six of the seven areas used for evaluation purposes. Although the reductions were generally small in magnitude (about 20 ppb), the percentage reductions were significant (40-60 percent outside the barrier and 20-30 percent inside the barrier). For dye sources in Jamaica Bay, dye concentrations for plan 3 were reduced in all seven areas from those of the base test. In this case, the magnitudes of the reductions were considerably greater, especially inside the barrier (about 100-600 ppb), but the percentage reductions were of the same order as for the previous test.

49. The results of plan 3 tests for normal tide conditions indicated that this plan would have no adverse effects on tides, tidal currents (except in the vicinity of the barrier and Marine Parkway Bridge), or salinities in Jamaica Bay. Although no base test velocities were measured in the immediate vicinity of the barrier and the bridge, later testing indicated that the maximum values observed for plan 3 at sta 14 V-17 V were higher than for base conditions. These tests also demonstrated that plan 3 would have no detrimental effects on the diffusion and flushing of pollutants, either those discharged directly into Jamaica Bay or those discharged into Rockaway Inlet in the vicinity of the proposed barrier. The results of the model pollution tests do not prove conclusively that pollutants will be flushed from Jamaica Bay as rapidly or more rapidly under plan 3 conditions than under existing conditions, since sampling performed was not sufficiently comprehensive to account for all dye released at all stages of the model tests. However, the fact that average dye concentrations for plan 3 were lower

than those of the base test in essentially all areas used for evaluation suggests strongly that the flushing characteristics of the bay would be improved by the construction of plan 3.

Plan 6

50. For plan 6, the navigation opening was 110 ft wide and the total number of tide gates was increased to 16; so the total area of opening with all gates open was 34,830 sq ft, including the area of the ungated navigation opening, as compared with a total area of 33,300 sq ft for plan 3. All gates were open during normal tide tests of plan 6, and all gates were closed during hurricane surge tests. The question of whether or not a dye diffusion test of plan 6 was required was discussed in detail during a conference attended by representatives of the Environmental Protection Agency (EPA) (then FWPCA). The decision of those representatives was that dye diffusion tests were not required, since the total opening area of plan 6 exceeded that of plan 3 by about 1,530 sq ft; thus, the effects of plan 6 on the diffusion and flushing of pollutants should result in improved conditions.

51. The effects of plan 6 on tides, current velocities, and salinities are shown in Plates 29-32, 33-55, and 56-73, respectively. The effects of this plan on tides, current velocities, and salinities were very similar to the effects of plan 3 (see paragraphs 43 and 49), as could be expected since the total opening area for these two plans was nearly the same.

52. The results of plan 6 tests for normal tide conditions indicate that this plan would have only very minor effects on tides, current velocities (except in the vicinity of the barrier and Marine Parkway Bridge), and salinities. Again, maximum velocities at sta 14 V-17 V were higher than those for base condition, although there were no corresponding base test data to show this conclusively. Where minor differences between the effects of plans 3 and 6 were noted, the effects of plan 6 were generally less than those of plan 3 because of the slightly greater total opening area of plan 6. The conclusion reached by representatives of EPA that the effects of plan 6 on the diffusion and flushing of pollutants should result in improved conditions is considered to be reasonable.

Phase 2: Schemes to Enhance Circulation Within Jamaica Bay

53. This phase was devoted to studying different schemes to enhance circulation of Jamaica Bay waters for the purpose of improving water quality along the northern bay beaches (i.e., Bergen Beach, Canarsie Beach, etc.). Two general schemes were employed; the first involved gate operations and a deflection dike, and the second consisted of various improvements (levees, submerged sills, and dredging) inside the bay. Each general scheme and its effects on circulation and/or velocity regimes is discussed in the following paragraphs.

54. All tests were conducted using a repetitive mean tide with a range of 4.7 ft and a duration of 12.42 hr (one cycle) at the Sandy Hook USC&GS gage and with a range of 7.2 ft at Willets Point at the western extremity of Long Island Sound. The freshwater inflow rates were 12,000 and 1,770 cfs in Hudson River and Raritan River, respectively. Atlantic Ocean salinity was maintained at 30 ppt throughout the tests, and the model was operated until salinity had stabilized prior to collecting any data. These early tests were conducted before the model roughness arrangement was revised; therefore, the test results are compared with the 1967 base test.

Gate operations with a deflection dike

55. The two plans tested in this scheme, plans 8-A and 15-A, are shown in Plates 74 and 75, respectively, and involved a hurricane surge protection structure with a total of 22 gated tidal passages 75 ft wide and 26 ft deep (msl) and an ungated navigation opening 200 ft wide with a sill constructed to el -24.3 ft msl. The tidal passages were arranged so that there were 11 passages on each side of the navigation opening. Each plan incorporated a curved deflection dike which began about 2000 ft east of the surge protection structure and ended near Nova Scotia Bar in Jamaica Bay. For plan 8-A, the surge protection barrier was located 1000 ft east of the Marine Parkway Bridge, and the distance from the surge protection barrier to the end of the deflection dike was approximately 2000 ft. Plan 15-A consisted of the barrier located

approximately 300 ft west of the Marine Parkway Bridge, and the end of the deflection dike was 2000 ft from the Marine Parkway Bridge. The locations of tidal and velocity stations are designated in Plates 74, 75, and 76, respectively, for plan 8-A, plan 15-A, and the base test.

56. The plans were first tested to determine if a clockwise net circulation could possibly be induced in Jamaica Bay to enhance water quality. For both plans, it was attempted to generate the clockwise circulation desired by operating the tidal passage gates in the following sequence: (a) during the flooding phase of the tidal currents, the 11 gates in the passages north of the navigation opening were fully opened, while the 11 gates in the passages south of the navigation opening remained closed; and (b) during the ebbing phase of the tidal currents, the gate operation procedure was reversed. The deflection dike was incorporated initially to divert the flood flow to the north into Island Channel.

57. For plans 8-A and 15-A, with the tidal gate operation as described in paragraph 56, the following effects on tidal heights were noted. At the Parkway West Station (Plate 77), tidal heights were increased by about 0.1 ft throughout the tidal cycle. The effects of gate operation were more pronounced east of the hurricane surge protection barrier or inside Jamaica Bay. The phases of the tides within the bay were delayed by about 45 min (Plates 78-82), as compared with base conditions. The planes of high and low water were generally increased by 0.1 or 0.2 ft, but there was no noticeable change in the range of tide within the bay as a result of gate operation.

58. Velocity observations at stations 500 ft east and west of the navigation opening for plans 8-A and 15-A (Plates 83 and 84) were comparable to measurements made at similar stations for plans 3 and 6, the two protection plans tested during phase 1. For plans 8-A and 15-A involving gate operation, the current velocities near the hurricane surge protection barrier were greatly altered as compared with base conditions. Flood velocities east of the structure and ebb velocities west of it were increased to a maximum of about 5.6 and 6.7 fps, respectively. These should not, however, be construed to represent the

maximum velocities through the 200-ft-wide navigation opening.

59. This phenomenon can also be detected by close examination of the surface current patterns in Photos 1-13, which include a base test photo and a plan photo made at the same hour during the respective tests. All photos are 3-sec time exposures of confetti floating on the water surface, and the streak length shows the total travel of confetti squares during the exposure interval. A strobe light was flashed just prior to closing the camera lens, resulting in a dot near the end of each streak to indicate the direction of flow. The magnitude of current velocities can be determined by measuring the lengths of the confetti streaks and comparing the lengths with the velocity scale shown in all photos. The velocities determined in this manner are true surface measurements and are generally slightly higher than surface measurements made with the current meters, since the current meter measurements are of necessity made several feet below the actual water surface.

60. For both plans tested, the deflection dike shown in Plates 74 and 75 caused a crosscurrent just east of the barrier during flood flow with a maximum magnitude of about 3 fps during hours 4-6 of the tidal cycle. This crosscurrent would probably be objectional to navigation interests and is shown in Photos 5-7. Lesser crosscurrent magnitudes existed during other portions of the flood phase of the tidal cycle.

61. Although visual dye tests indicated that a net clockwise circulation developed in the bay using either of the two plans discussed above, this scheme was abandoned because of the adverse velocity conditions generated by gate operations which caused magnitudes of 6.0 fps or greater, and by the deflection dike, which caused crosscurrents hazardous to navigation.

Interior improvement plans

62. These schemes consisted of a hurricane surge barrier, levees, submerged sills, and/or extensive dredging. Tests of the schemes consisted of visual observation of the movement of slug releases of dye. It should be noted that wind stress is probably the most important energy agency for circulation in this shallow bay, but wind is not simulated in the model.

63. Plates 85-101 provide sketches of the essential parts of each scheme tested to improve circulation within Jamaica Bay. Dye injection locations are noted, as well as the time of release (either low-water slack (LWS) or high-water slack (HWS)). The extent of the flood and/or ebb excursion of the dye was determined visually and is also indicated in these plates. None of the schemes tested showed a marked increase in the clockwise circulation.

Phase 3: Hurricane Surge Tests of Various Barriers with Ungated Navigation Openings

64. The hurricane surge tests were conducted with the November 1950 surge and the Standard Project Design surge. These tests did not include astronomical tides, since the phasing of the hurricane surge and the astronomical tide is critical to the maximum water level, as shown by comparing prototype water level histories at Fort Hamilton for the November 1950 surge in Plates 23 and 28. Without the astronomical tide, the maximum water level was 8.0 ft at about hour 7 in the second half of the surge, whereas, with the tide, the maximum water level was about 7.5 ft at hour 9 of the first half of the surge. The astronomical tide easily can be added analytically to the surge for any desired phase relation.

65. The two hurricane surges used for test purposes are shown in Figure 11. The November 1950 surge is a surge of record and was selected for testing because of the very long duration of the surge (the rising phase covered about 21 hr). The second is the Standard Project Design surge, the computed surge that would be produced by a hurricane of maximum intensity moving over the study area on a critical path.

Plan 3

66. The results of the hurricane surge tests of plan 3 are summarized in Table 5. The width and depth of the ungated navigation opening also are listed (dimensions of the gated openings are given in Table 2). For the hurricane surge tests, the gated openings were closed, and only the ungated navigation opening was available for passage of the surge through Rockaway Inlet.

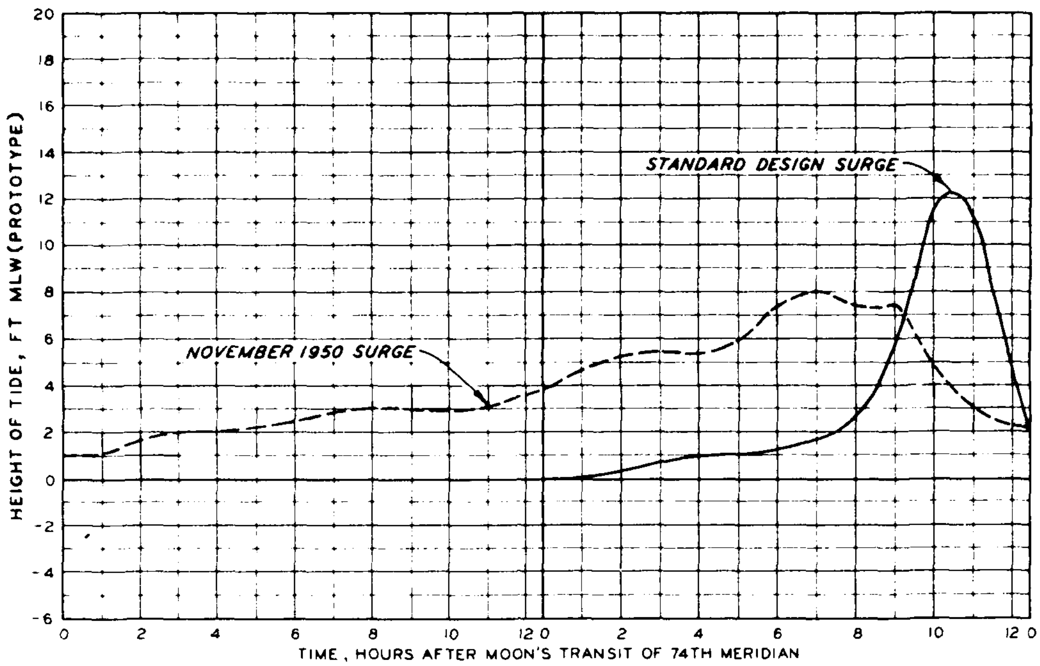


Figure 11. November 1950 and standard design surges minus normal tides at Fort Hamilton

67. The maximum elevation recorded in Jamaica Bay for the Standard Project Design surge base test was +11.2 ft msl, which was reduced to +4.8 ft msl by plan 3 (Table 5). For the November 1950 surge, this table shows that the maximum base test elevation of +8.4 ft msl was reduced to +6.6 ft msl by plan 3.

68. Plan 3 was effective in reducing the maximum height of the Standard Project Design surge in Jamaica Bay to less than +5.0 ft msl, the elevation at which damage by flooding begins. However, for conditions of the long-duration surge that occurred in November 1950, the maximum elevation observed in Jamaica Bay with plan 3 installed in the model was +6.6 ft msl, or 1.6 ft above the level at which damage begins. Therefore, while it appears that plan 3 would satisfy all of the design criteria for normal tides (as determined in phase 1 testing), as well as affording adequate protection from flooding for conditions of the higher hurricane surges of relatively short duration (a rising phase of 8-10 hr), plan 3 would yield less benefits from flooding for conditions

of long-duration surges (a rising phase of 20 or more hr) similar to that produced by the November 1950 hurricane.

Plans 4, 5, and 6

69. Since the results of surge tests of plan 3 demonstrated that a 300-ft-wide ungated opening at natural depth (about -33 ft msl) would not afford the desired protection for flooding for conditions of the November 1950 surge, three additional plans for an ungated navigation opening were developed for testing. These plans all incorporated an ungated opening at natural depth, and the widths of the opening were 200, 150, and 110 ft for plans 4, 5, and 6, respectively. Based on the results of discharge rating tests in the undistorted-scale model, it was concluded that neither plan 4 nor plan 5 would afford the desired suppression of the November 1950 surge, but plan 6 should afford the desired suppression. Thus, no further testing was done for plans 4 and 5, but an ungated opening for plan 6 was calibrated for distorted-scale model testing.

70. The effects of plan 6 on hurricane surges are shown in Table 5, and the dimensions of the ungated and gated elements of the plan are listed in Table 2. As noted in Table 5, the maximum elevation reached in Jamaica Bay for conditions of the Standard Project Design surge was +2.8 ft msl, and the maximum elevation reached for conditions of the November 1950 surge was +5.0 ft msl. In comparison, the maximum elevations recorded for these surges for base test conditions were +11.2 ft and +8.4 ft msl, respectively, while the maximum elevations reached for plan 3 were +4.8 ft and +6.6 ft msl, respectively.

71. The results of the hurricane surge tests of plan 6 demonstrate that this plan would afford greater protection from flooding by hurricane surges, both for conditions of the higher, shorter duration surges and the long-period surges of less amplitude. However, at this point in the study, navigation interests in Jamaica Bay were contacted concerning the minimum width of ungated opening that could be safely navigated by vessels then in service or planned for the future, and replies received from such interests indicated that an opening width of about 150 ft was the minimum that could be tolerated. (The 150-ft

criterion was later revised upward to a 200-ft minimum width with a maximum submerged sill of -24.3 ft msl as shown in plan 10.) Accordingly, three additional plans (plans 7, 8, and 9), each having an ungated navigation opening width of 150 ft or more and each with submerged sills, were devised and tested to determine if a plan could be developed that would satisfy both the requirements of surge suppression and safe navigation.

Plans 7, 8, and 9

72. The significant features of plans 7, 8, and 9 are listed in Table 2. Plans 7 and 8 had an ungated navigation opening width of 150 ft, with submerged sills at -26 ft and -23 ft msl, respectively. Plan 9 had an ungated navigation opening width of 200 ft with a submerged sill at -23 ft msl. Each of these plans incorporated sixteen 75-ft-wide tide gates with sills at -26 ft msl; therefore, the total opening areas with all gates open were 35,100 sq ft, 34,650 sq ft, and 35,800 sq ft for plans 7, 8, and 9, respectively. In comparison with plans 3 and 6, the smallest of these areas (34,650 sq ft for plan 8) was 1,350 sq ft greater than for plan 3 and 180 sq ft less than for plan 6.

73. Plans 7, 8, and 9 were tested in the undistorted-scale model for discharge rating purposes, and distorted-scale models of each plan were calibrated for surge testing in the New York Harbor model. The results of the surge tests are shown in Table 5. For the Standard Project Design surge, the maximum elevations reached in Jamaica Bay were +3.3 ft, +2.9 ft, and +3.7 ft msl, respectively, for plans 7, 8, and 9. For the November 1950 surge, the maximum elevations reached in Jamaica Bay were +5.6 ft, +5.3 ft, and +6.0 ft msl, respectively, for plans 7, 8, and 9.

74. The results of surge tests in the New York Harbor model demonstrated that plans 7, 8, and 9 yielded levels intermediate to those of plans 3 and 6 for flooding in Jamaica Bay by surges similar to the November 1950 surge. While none of these plans were tested for effects on tides, current velocities, salinities, or the diffusion and flushing of pollutants for normal tide conditions, such effects should be less

of a change than those of plan 3, since the total opening area of plans 7, 8, and 9 exceeded that for plan 3.

Plan 10

75. The significant features of plan 10 are listed in Table 2. Plan 10 had an ungated navigation opening width of 200 ft, with a submerged sill of -24.3 ft msl. This navigation opening represents the minimum-size opening acceptable to navigation interests.

76. The navigation opening for plan 10 was not tested in the undistorted-scale model for discharge rating. A distorted-scale model was prepared for surge testing in the comprehensive model with interpolated data from the undisturbed-model facility. The results of the surge tests are shown in Plates 102-109. These plots are presented because the navigation opening portion of the plan 10 barrier is identical to that of the plan C-1 barrier, which was subsequently subjected to comprehensive testing. The most significant results are shown in Table 5. For the Standard Project Design surge, the maximum elevation recorded in Jamaica Bay was 3.9 ft msl; for the November 1950 surge, the maximum elevation in the bay was 6.0 ft msl.

77. The results of surge tests of plan 10 show that, with the minimum acceptable navigation opening criteria of 200-ft width and a sill no shallower than -24.3 ft msl, the maximum suppression in flooding levels within Jamaica Bay due to the November 1950 and the Standard Project Design surges would be 2.4 and 7.3 ft msl, respectively.

Summary of results of surge tests

78. The results of all surge tests of the various barrier designs studied in the New York Harbor model are summarized in Figure 12. In this figure, the maximum elevation recorded in Jamaica Bay is plotted as a function of the area of the ungated navigation opening below mean sea level for each plan tested, and best-fit curves (visual) have been drawn for tests involving both the Standard Project Design surge and the November 1950 surge. For all plans except plan 6, the plotted points fit the smooth curves quite well. In this plan, it appears that additional head loss was introduced by some factor other than opening area, since the points for both surge conditions fall below the smooth curves. It

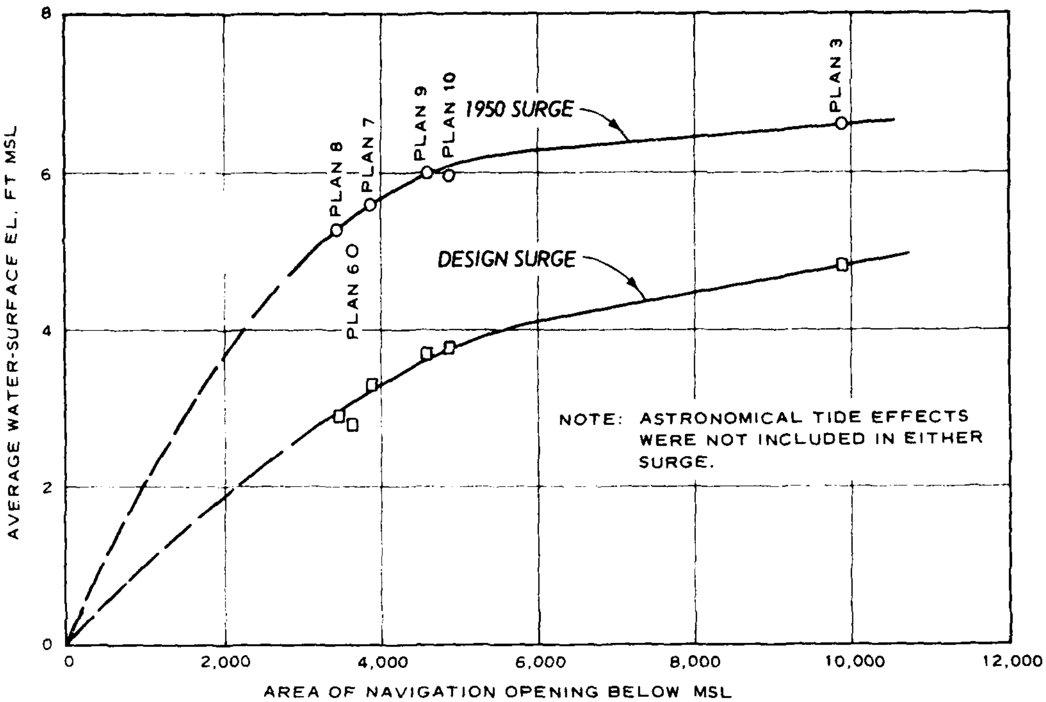


Figure 12. Average water-surface elevation versus area of navigation opening

is probable that turbulent eddies generated by flow past the abutments of the 110-ft-wide ungated opening of plan 6 actually extended completely across the opening, and such turbulence probably resulted in a greater total head loss per unit of area than the other plans tested. This probability should be considered in any use of the smooth curves in Figure 12 as a basis for determining the ungated opening area required to satisfy the design criteria for surge suppression.

Phase 4: Navigation Velocity Tests

79. In this phase of the study, tests were conducted to determine the effect of five plans on maximum velocities as they may affect navigation. All tests included a mean tide reproduced in the model. The critical dimensions of these plans (plans A, B, C-1, C-2, and C-3) are listed in Table 2. All of these barriers were located 500 ft east of the Marine Parkway Bridge with the center line of the navigation opening

coinciding with the center line of the navigation opening for the bridge. Each structure had an ungated navigation opening 200 ft wide (300 ft wide for plan B) with a sumberged sill at el -24.3 ft. Each structure incorporated tainter gate openings 75 ft wide with submerged sills at -26.0 ft. (See Appendix A, Plates A1 and A2, for details of plans C-1 and C-3, respectively.)

80. Velocity traverses were established across Rockaway Inlet as shown in Figure 13. Velocity measurement locations were designated with a letter for the particular traverse and a number for each individual station, i.e., A2 represents sta 2 on traverse A. Velocity measurements for these tests were made on traverses A, C, F, and G. Surface current photos were also made, so that the true surface velocities and patterns could be more readily seen.

81. The plan A barrier was subjected to calibration tests in the undistorted-scale model, and the distorted-scale model of the structure was based on those test results. After consideration of the procedures and results of tests of barrier plans in the undistorted-scale model, it was determined that for the low-head conditions in Rockaway Inlet a direct-scaled structure could be used. Therefore, plans B, C-1, C-2, and C-3 were tested using a new direct-scale structure (that is, the dimensions of the distorted-scale structure were determined directly by application of the horizontal and vertical model scales to the appropriate prototype dimensions).

82. Barrier plan A had 31 tainter gates. The distorted-scale model gate dimensions were developed from tests in an undistorted-scale model. Barrier plan B consisted of a 300-ft-wide navigation opening and forty 75-ft-wide tainter gates, 17 north of the navigation opening and 23 south. Barrier plan C-1 was identical to plan B except that plan C-1 had a 200-ft-wide navigation opening. Barrier plans C-2 and C-3 were the same as plan C-1 except that for plan C-2, the northernmost tainter gate and the two southernmost tainter gates were removed, leaving a total of 37 tainter gates; and for plan C-3, the two northernmost gates and the three southernmost gates were removed, leaving a total of 35 tainter gates.

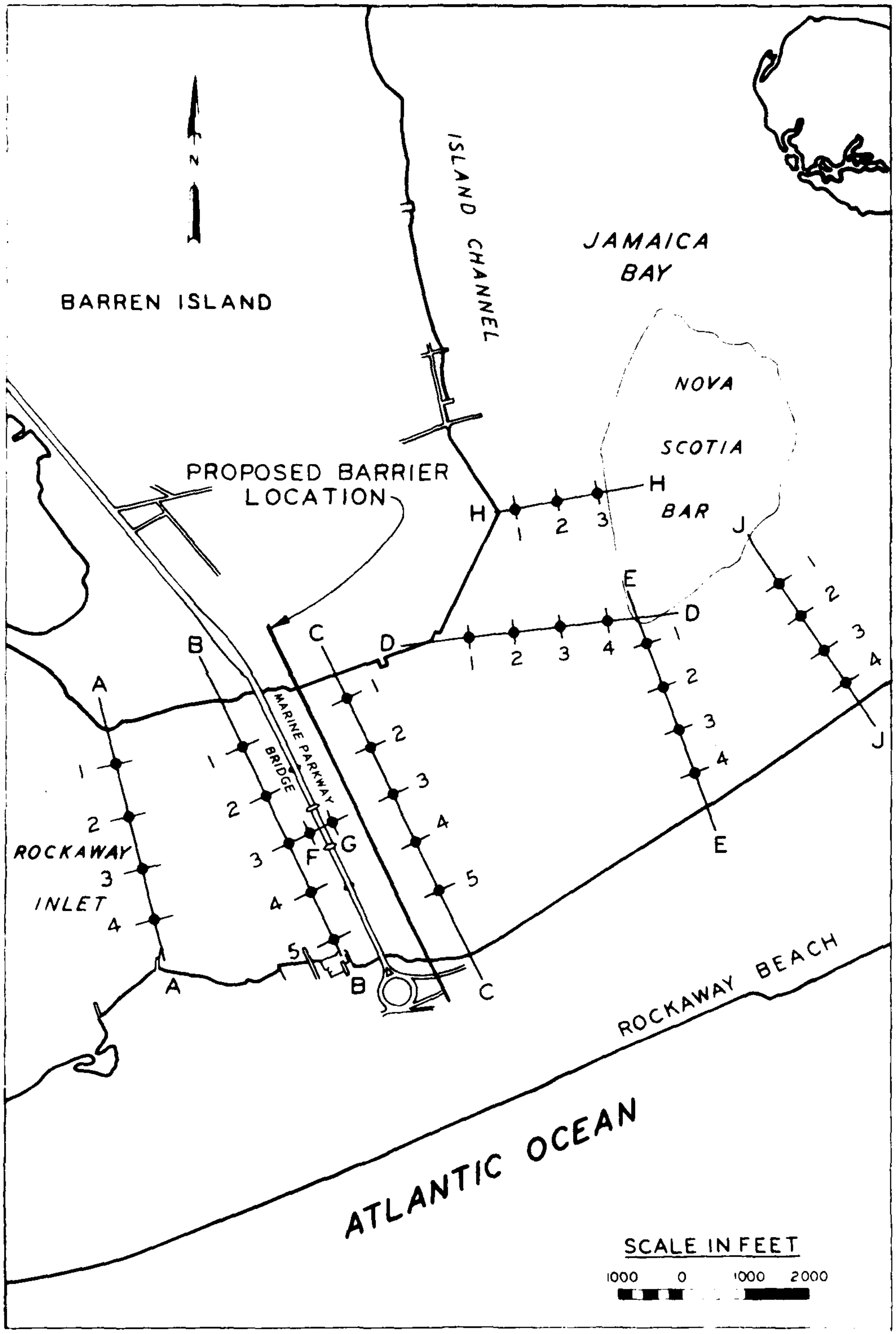


Figure 13. Location of velocity traverses across Rockaway Inlet

83. Inspection of the maximum velocities in the vicinity of the barrier (Table 6) for the base (1974) and plan tests shows that the maximum velocity at any station was increased by 0.1-0.8 fps by each plan with the exception of plan B where the maximum flood velocity was unchanged and the maximum ebb velocity was reduced by 0.3 fps. The most critical locations from a navigation concern are sta C-3 and G (Figure 13) located immediately east and west of the navigation opening, respectively. For the flood phase of the tide (Figure 14 and Table 6), significant increases in velocity occurred east of the navigation opening., whereas, during the ebb phase (Figure 15 and Table 6), significant increases in velocity were evident immediately west of the navigation opening (which is also immediately east of the navigation opening of the existing bridge). Prior to installation of the plans, the maximum velocities recorded were at traverse A (A3 for flood and A1 for ebb). The location of maximum velocity during flood shifted to sta C-3 for all plans. The maximum velocities for ebb varied in location from traverse A and sta G depending on the plan. Base velocity data for traverses B, D, E, H, and J are shown in Table 7, although no plan data were obtained for any of these stations.

84. Table 8 shows the tidal elevations in feet mean low-water (mlw) for plans C-1, C-2, and C-3 on both sides of the surge barrier. The maximum head difference (Δh) found was 0.2 ft. If the modified orifice equation

$$V = C_d \sqrt{2g\Delta h}$$

where

V = velocity, fps

C_d = coefficient of discharge

g = gravitational acceleration, ft/sec^2

is used with C_d assumed as 0.90, then the maximum velocity expected would be for the maximum Δh experienced. In this case with Δh = 0.2 ft , V_{max} would equal 3.2 fps. This value agrees well with the velocities measured in the model.

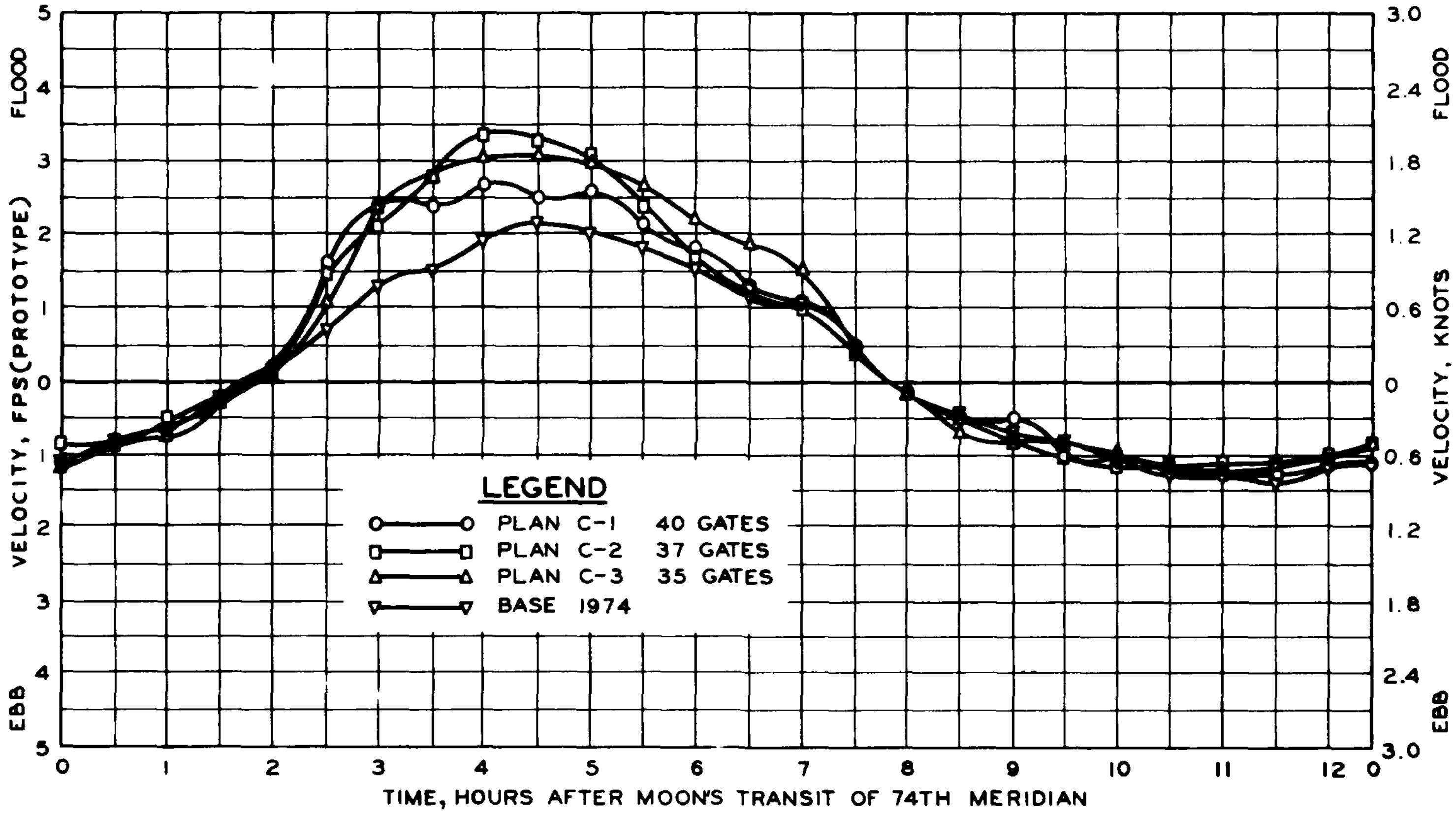
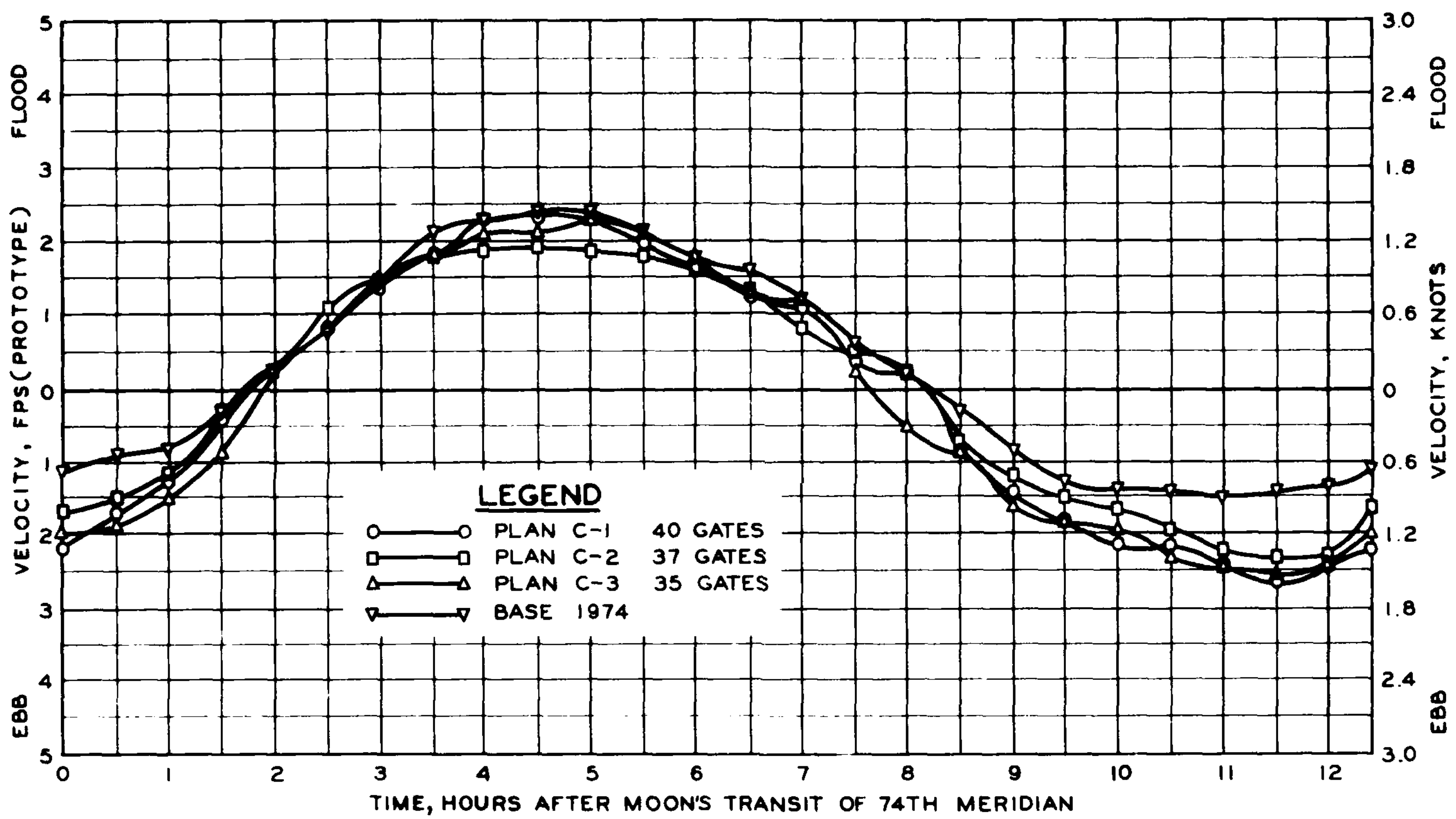


Figure 14. Effects of barrier on velocities at sta C-3 surface



F. ure 15. Effects of barrier on velocities on sta G surface

85. Figure 16 shows log-log plots of the percent of total inlet cross-sectional area available for flow as a function of maximum velocity (flood and ebb). It is included to show the increase in maximum velocity associated with a decrease in cross-sectional area. The plot was generated from model data, and the curves were developed through use of a least-squares computational routine. The bands presented with each curve indicate the possible maximum error induced by the accuracy limits of the velocity meters. Photos 14-26 show surface current velocities for the base test (1974) and plans B, C-1, C-2, and C-3. The following tabulation lists the maximum velocity magnitudes found from these surface current photos for three areas in the vicinity of Rockaway Inlet:

Area	Prototype, fps				
	Base (1974)	Plan B	Plan C-1	Plan C-2	Plan C-3
			Maximum Flood		
Traverse A	3.0	2.1	2.7	3.0	2.8
Navigation opening, bridge or barrier	3.2	3.0	2.7	3.1	3.1
Traverse D	2.8	2.3	2.6	3.1	2.8
			Maximum Ebb		
Traverse A	3.4	2.9	3.1	3.4	3.4
Navigation opening, bridge or barrier	2.9	2.5	2.7	2.5	2.8
Traverse D	2.8	2.0	2.3	2.6	2.8

86. After an analysis of the results of the hurricane surge tests of phase 3 and the navigation velocity tests discussed above, it was decided that, of the many barrier plans tested, plan C-1 provided the necessary surge protection and did not generate velocity conditions hazardous to navigation. The constraints imposed by Jamaica Bay navigation interests on the minimum size of the ungated navigation opening, i.e. 200 ft wide with a sill no shallower than -24.3 ft, also were satisfied by plan C-1. Therefore, plan C-1 was selected for comprehensive testing.

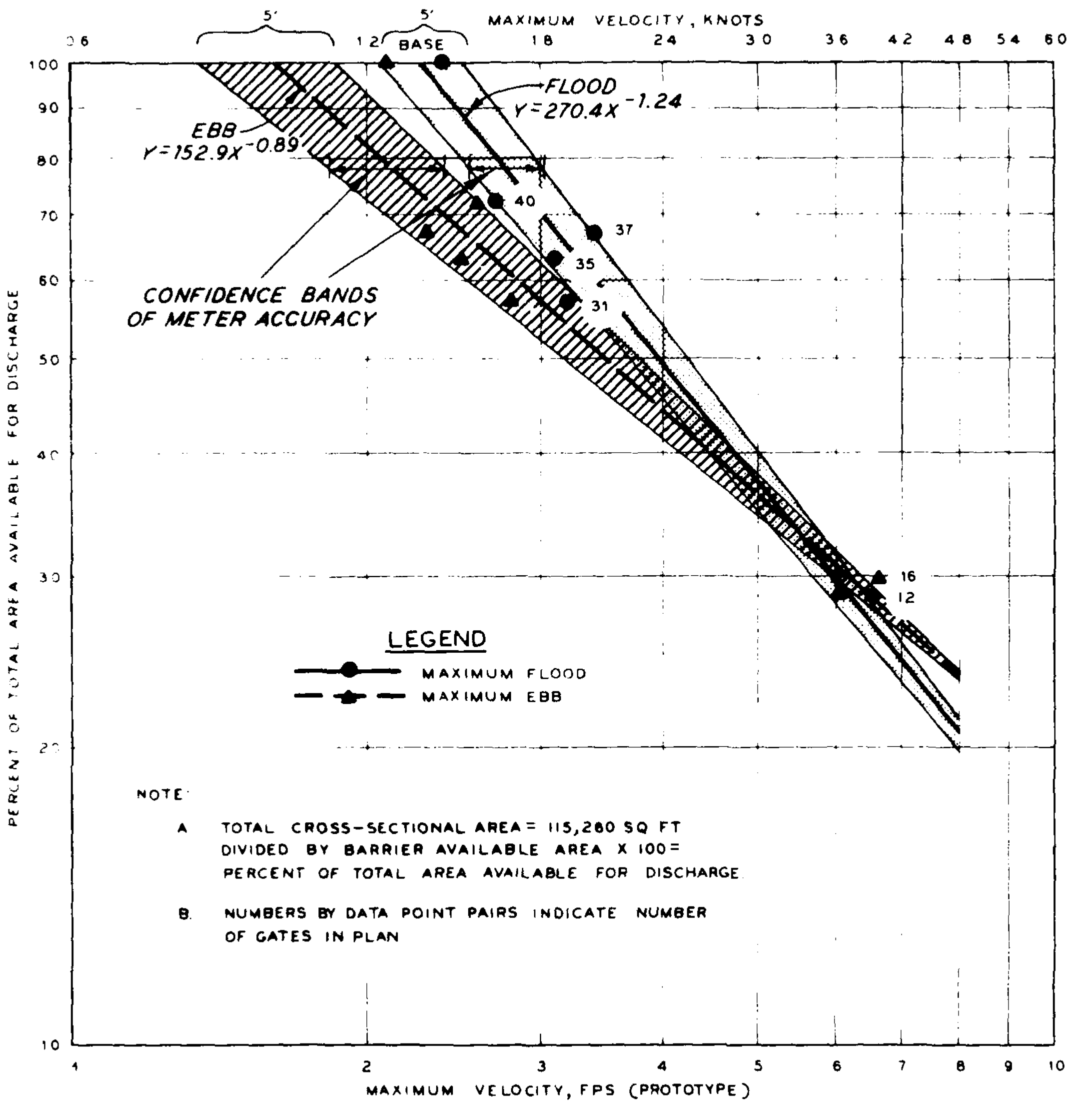


Figure 16. Total area for discharge versus maximum velocity near navigation opening

Phase 5: Comprehensive Testing of Barrier Plan C-1

87. Barrier plan C-1 was subjected in this phase to a testing series similar to the series employed in phase 1, the two key differences being that the tidal-phase adjustment had been completed and that the dye dispersion test consisted of two slug releases instead of the continuous release used in phase 1.

88. Test control conditions for all testing in phase 5 consisted of the following:

a. Repetitive mean tides were generated at the model ocean and Long Island Sound headbays with ranges of 4.7 ft at Sandy Hook and 7.2 ft at Willets Point.

b. Ocean or source salinity was maintained at 30-ppt total salt. Salinity stability was established in the model before any data were collected.

c. Hudson River and Raritan River had sustained freshwater inflows of 12,000 cfs and 1,770 cfs, respectively. Known average prototype discharges of fresh water into Jamaica Bay from the various sewage treatment plant outfalls were maintained (see Table 1 for prototype discharges used for 1974 testing).

89. The plan C-1 tests were for a hurricane surge protection barrier located 500 ft east of the Marine Parkway Bridge and parallel to the bridge. The barrier had a 200-ft-wide navigation opening and forty 75-ft-wide tidal passages. All tidal passages and the navigation opening remained in the fully open position for all the plan tests in phase 5. The navigation opening had a bottom sill at el -24.3 ft msl, and the tidal passages had bottom sills at el -26.0 ft msl.

90. The effects of plan C-1 on tidal heights within Jamaica Bay are shown in Table 9. Sandy Hook was the model control station; thus, discrepancies between the base and the plan at that location represent inaccuracies in generating the tide at the model boundary rather than effects of the plan. A slight phase shift (about 15 to 20 min) is evident at all of the stations bayward of the barrier. Mean tide levels (MTL), however, were not changed significantly; therefore, it is concluded that plan C-1 will slightly delay the arrival of high or low water within the bay.

91. The effects of the barrier plan on current velocities are shown in Plates 110-130 and Tables 10-30. Stations 1 V, 2 V, and 3 V (Plates 110-112) show a slight phase shift (less than 30 min) but no significant changes in the magnitudes of maximum flood currents. Small increases (0.2 to 0.3 fps) in the maximum ebb velocities were experienced at sta 1 V and 3 V with the exception of the bottom measurements at sta 1 V, and a slight decrease (0.4 to 0.6 fps) in maximum ebb velocity occurred at all depths at sta 2 V. Stations 14 V and 15 V (Plates 123 and 124), seaward of the barrier, show a reduction (0.4 fps) in maximum flood velocities and a slight increase (0.3 to 0.5 fps) of maximum ebb velocities at the surface. Bottom maximum ebb velocities were decreased from 0.4 to 1.0 fps at both sta 14 V and 15 V. Station 16 V (Plate 125), bayward of the barrier, shows an increase (0.4 fps) in the magnitude of the maximum flood velocity on the surface, and both sta 16 V and 17 V show a decrease of 0.5 to 1.2 fps in the maximum ebb velocities at both surface and bottom depths. Flood velocities were decreased 0.3 fps on the bottom at both stations. The stations located along Beach Channel in the bay, 0 BCH and 1 BCH (Plates 121 and 122), 4 V (Plate 113), 4 BCH (Plate 127), and 7 V (Plate 116), and those stations located in the entrances to Grassy Bay, 8 V and 9 V (Plates 117 and 118), experienced a slight phase shift (15 to 20 min) but approximately the same velocity magnitudes. The stations located in Island Channel, 7 ICH, 9 ICH, 11 ICH (Plates 128-130), and 6 V (Plate 115), experienced no significant changes except that 7 ICH exhibited no surface ebb velocity which could be attributed to the barrier. Station 5 V (Plate 114), located near Canarsie Pol in the tidal flats, shows a slight reduction (0.4 fps) in the maximum flood velocity but no other significant change.

92. The effects of the barrier plan on salinities are shown in Plates 131-147. No significant changes in salinities were detected; however, salinities were consistently increased at all the stations along Beach Channel. The variations indicated in the plots either are within the meter accuracy of ±2 percent or are attributed to experimental error.

The salinity differences are not considered to be due to installation of the barrier.

93. The dye dispersion tests were conducted in the following manner. Two release points were established, the Coney Island Plant outfall terminus and a point adjacent to Bergen Beach (Plate 1). A conservative fluorescent dye adjusted to an initial concentration of 100,000 ppb was released at a constant rate for one tidal cycle at each release point. At the Coney Island plant outfall, the dye release rate was 1,000 cc/min so that a total of 7.450 ℓ of the dye solution was introduced into the model. At the Bergen Beach release point, the rate was 500 cc/min so that a total of 3.725 ℓ of dye solution was introduced into the model during the release cycle. Separate tests were conducted for each release point. After completing the dye releases, water samples were taken at 34 stations shown in Plate 1 every other cycle for 10 cycles and then every fifth cycle until cycle 95. A fluorometer was then used to measure in ppb the concentration of dye present in each sample. The results of the dye dispersion tests for both the base and the barrier plan are summarized in Tables 31 and 32 for the Coney Island Plant and Bergen Beach release points, respectively.

94. For ease of analysis, the region seaward from the barrier was divided into three areas (the approach channel, Coney Island Beach, and the basins), and Jamaica Bay was divided into four areas (Beach Channel, Island Channel, the tidal flats, and the basins). The results of all sampling performed in each area for the first 10 tidal cycles were averaged, and the average concentrations thus determined are shown in Table 31 for the dye source seaward from the barrier location and in Table 32 for the dye source bayward from the barrier location. For the dye source seaward of the barrier, average dye concentrations for the barrier plan were increased slightly in most areas in Jamaica Bay as compared with similar values determined for the base test. Although the magnitude of these increases was generally quite small, the changes in Beach and Island Channels were on the order of 25 to 50 percent. Outside Jamaica Bay, concentrations were slightly reduced in magnitude or unchanged. For the dye source in Jamaica Bay, averge dye concentrations

for the barrier plan were increased within Jamaica Bay but were reduced in the areas outside the bay. Substantial changes in magnitude for their release were indicated at several sampling locations in Island Channel (686 ppb maximum), the tidal flats (297 ppb maximum), and the basins inside Jamaica Bay (645 ppb maximum). Percentagewise, these changes ranged from essentially no change to increases of about 100 percent. Outside Jamaica Bay, the results showed small magnitude changes but percentage changes as great as about 80 percent.

95. The proposed 40-gate barrier plan C-1 did cause some changes to the flow distribution through Rockaway Inlet (small increases and reductions in maximum velocities were observed at various locations), but the changes were not of significant magnitude to create a hazard or make navigation more difficult in the inlet. Dispersion in Jamaica Bay seems to have been affected by the barrier. Based on results of the phase 5 testing, the following conclusions have been reached with respect to plan C-1:

a. Tidal heights and range will not be affected, but a slight phase lag (or arrival delay) will occur at stations within Jamaica Bay.

b. Velocities at stations located near the barrier will exhibit the most changes (increase of magnitude at seaward stations on ebb, and increase of magnitude at bayward stations on flood). Stations within Jamaica Bay will show a slight phase shift.

c. No significant changes in the salinity regime of Jamaica Bay will occur. The bay will remain well mixed.

d. For the conservative dye source seaward of the barrier, average dye concentrations will be increased slightly in most areas in Jamaica Bay. For the conservative dye source within Jamaica Bay, average dye concentrations will be increased within the bay but will be reduced in areas outside of the bay.

PART V: CONCLUSIONS

96. The following conclusions are based on the results of the model testing program:

<u>a</u>. For the sizes of ungated navigation openings considered in this study, a slow rising hurricane surge with a moderate peak water level (similar to the November 1950 surge) produces higher water levels behind the surge barrier in Jamaica Bay than does the Standard Project Design surge, which has a considerably higher peak water level but a much faster rate of rise.

<u>b</u>. A relationship was developed for the cross-sectional area of navigation opening required to achieve various degrees of suppression of the maximum water-surface level (to heights from 5.0 to 6.6 ft) in Jamaica Bay for the November 1950 hurricane surge without astronomical tides (Figure 10).

<u>c</u>. The maximum velocities for mean tide condition near the navigation opening that can be expected to be experienced by boat traffic vary directly with the total cross-sectional area of the navigation opening and tidal openings (Figure 15).

<u>d</u>. Barrier plans B, C-1, C-2, and C-3 would have the least effect on the hydraulics of the Jamaica Bay area. Tide phases would be shifted slightly. The magnitudes and locations where current velocities are the greatest in the throat of Rockaway Inlet are increased and shifted, respectively.

<u>e</u>. Dye dispersion with barrier plan C-1 with a conservative dye source seaward of the barrier indicated that average dye concentrations will be increased slightly in most areas in Jamaica Bay. For the conservative dye source within Jamaica Bay, average dye concentrations will be increased within the bay but will be reduced in areas outside of the bay.

<u>f</u>. Barrier plan 3 would require the smallest area of gated tidal passages to maintain existing conditions with respect to salinities and pollution dispersion. During the testing program, however, it became evident that velocities in Rockaway Inlet with respect to safe navigation were a more stringent criterion and that barrier plan C-1 would satisfy both the pollution dispersion and safe navigation criteria.

g. Tests conducted to develop an operative scheme of gate operation to improve circulation in Jamaica Bay indicated

that improved conditions could be obtained; however, very adverse navigation conditions also occurred consisting of definite crosscurrents and areas of relatively high velocities.

h. Tests conducted with various levees, submerged sills, and/or dredging within Jamaica Bay did not result in significant improvements in the flushing of Jamaica Bay.

PART VI: FUTURE MODELING

97. Assuming the hurricane barrier is ultimately approved, construction phasing of the barrier structure will no doubt result in higher local velocities and unfavorable currents while the cofferdams are in place. Therefore, it will be necessary to plan the cofferdam stages through model tests so as to obtain the least disturbance to shipping while the project is under construction. In addition, the erosion characteristics of the navigation opening and the flow passages under the tainter gates will require future testing in a model. These tests would determine the type of protection required and the necessary dimensions.

REFERENCES

1. Simmons, H. B. and Bobb, W. H., "Hudson River Channel, New York and New Jersey, Plans to Reduce Shoaling in Hudson River Channels and Adjacent Pier Slips," Technical Report No. 2-694, Sep 1965, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

2. Wilson, B. W., "The Prediction of Hurricane Storm-Tides in New York Bay," Final Technical Report No. 165-2, Jan 1959, Texas A&M University Research Foundation, College Station, Tex.

3. Leendertse, J. J., "A Water-Quality Simulation Model for Well Mixed Estuaries and Coastal Seas; Volume IV, Jamaica Bay Tidal Flows," R-1009-NYC, Jul 1972, The Rand Corporation, New York, N. Y.

4. Leendertse, J. J. and Liu, S.-K., "Comparison of Observed Estuarine Tide Data with Hydraulic Model Data by Use of Cross-Spectral Density Functions," R-1612-NYC, Sep 1974, The Rand Corporation, New York, N. Y.

5. Multer, R. H., "Artificial Roughness in Distorted Hydraulic Models of Estuaries" (unpublished paper), Jan 1974, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

6. Leendertse, J. J. and Liu, S.-K., "A Water-Quality Simulation Model for Well Mixed Estuaries and Coastal Seas; Volume VIII, an Engineering Assessment," R-1791-NYC, Dec 1975, The Rand Corporation, New York, N. Y.

Table 1

Prototype Flows Simulated During Tests

Name of Plant	Prototype Combined Outflow, mgd 1967*	1974**
Sheepshead Bay overflow	1.2	1.2
Coney Island Plant and overflow	83.25	126.0
Paerdegat Basin overflow	14.2	14.2
Fresh Creek overflow	6.9	6.9
26th Ward Plant and overflow	50.0	80.0
Bergen Basin overflow	5.0	5.0
Jamaica Plant outfall	50.2	92.0
Thurston Basin overflow	9.2	9.2
Rockaway Plant and overflow	17.6	21.0
Total	237.55	355.50

* Prototype outflows simulated during salinity verification and dye dispersion tests of phase 1.

** Prototype outflows simulated for model tests of phases 2, 4, and 5.

Table [illegible]

Barrier Dimension Summary

Plan No.	Phase*	Ungated Navigation Opening: Width ft	Ungated Navigation Opening: Depth ft, msl	Ungated Navigation Opening: Area Below msl, sq ft	Gated Openings 75 by -26 ft msl: No. of Gates	Gated Openings 75 by -26 ft msl: Area Below msl, sq ft	Total Area Below msl, sq ft	Miscellaneous Notes	New York District Coordinator
Base		3700	--	--	--	--	117,750	Total area = 115,260 sq ft, 500 ft East Marine Parkway Bridge	Base 1967, F. Panuzio; Base 1974, J. Rosen
3	1,3	300	33	9900	12	23,400	33,300	Comprehensively tested	F. Panuzio
4	3	200	33	6600	--	--	--	Undistorted model tests only	F. Panuzio
5	3	150	33	4950	--	--	--	Undistorted model tests only	F. Panuzio
6	1,3	110	33	3630	16	31,200	34,830	Comprehensively tested	F. Panuzio
7	3	150	26	3900	16	31,200	35,100	Surge tested only	F. Panuzio
8	3	150	23	3450	16	31,200	34,650	Surge tested only	F. Panuzio
9	3	200	23	4600	16	31,200	35,800	Surge tested only	F. Panuzio
10	3	200	24.3	4860	22	42,900	47,760	Surge tested only	J. Rosen
8-A	2	200	24.3	4860	22	42,900	47,760	Gate operated to enhance circulation	J. Rosen
15-A	2	200	24.3	4860	22	42,900	47,760	Gate operated to enhance circulation	J. Rosen
A	4	200	24.3	4860	31	60,450	65,310	Navigational velocity tests	J. Rosen
B	4	300	24.3	7290	40	78,000	85,290	Navigational velocity tests	J. Rosen
C-1	4,5	200	24.3	4860	40	78,000	82,860	Comprehensively tested	J. Rosen
C-2	4	200	24.3	4860	37	72,150	77,010	Navigational velocity tests	J. Rosen
C-3	4	200	24.3	4860	35	68,250	73,110	Navigational velocity tests	J. Rosen

* Phase 1: Earliest barrier schemes.
Phase 2: Schemes to enhance circulation within Jamaica Bay.
Phase 3: Hurricane surge tests of various barriers with ungated navigation openings.
Phase 4: Navigation velocity tests.
Phase 5: Comprehensive testing of barrier plan C-1.

Table [illegible]

Effects of Plan 3 on Average Dye Concentrations for Dye Sources

Seaward from Protection Barrier (Tidal Cycles 70-100)

Location	High-Water Slack Measurement, ppb						Low-Water Slack Measurement, ppb					
	Surface			Bottom			Surface			Bottom		
	Base 1967	Plan 3	Difference	Base 1967	Plan 3	Difference	Base 1967	Plan 3	Difference	Base 1967	Plan 3	Difference
Areas Outside Barrier												
Approach Channel												
[illegible]	26	11	-15	26	6	-20	25	6	-19	23	9	-14
[illegible]	27	7	-20	27	7	-20	70	44	-26	61	44	-17
[illegible]	[illegible]	118	-82	38	19	-19	89	47	-42	89	47	-42
[illegible]	[illegible]	28	-12	29	21	-8	63	45	-18	63	39	-24
[illegible] V	40	28	-12	28	17	-11	70	50	-20	62	50	-12
[illegible] V	43	28	-14	29	10	-19	82	44	-38	70	44	-26
Average			-26			-16			-27			[illegible]
[illegible] to Beach												
43 [illegible] IC	25	4	-21	[illegible]	4	-21	32	21	-11	32	10	-22
44 [illegible] IC	[illegible]	7	-11	18	7	-11	23	22	-1	23	12	-11
46 [illegible] IC	21	8	-13	21	8	-13	27	15	-12	27	11	-16
Average			-15			-15			-8			-16
Basins												
14 [illegible] BA	700	960	+260	84	95	+11	470	570	+100	56	78	+22
15 PB [illegible]	63	62	-1	63	9	-54	15	62	+47	15	9	-6
Average			+130			-22			+74			+8
Areas Inside Barrier												
Beach Channel												
26	56	32	-24	32	23	-9	85	50	-35	100	50	-50
27	81	54	-27	47	54	+7	77	49	-28	81	49	-32
0 BCH	67	--	--	52	--	--	44	--	--	52	--	--
1 BCH	109	62	-47	94	62	-32	74	54	-20	74	54	-20
4 V	86	62	-24	86	62	-24	77	54	-23	80	54	-26
4 BCH	70	50	-20	70	50	-20	68	50	-18	68	50	-18
7 V	64	50	-14	59	49	-10	59	49	-10	59	49	-10
[illegible] BCH	[illegible]	28	-47	72	28	-44	68	28	-40	68	28	-40
8 BCH	70	45	-25	70	45	-25	65	45	-20	65	45	-20
Average			-29			-20			-24			-27
Island Channel												
7 ICH	72	49	-23	64	40	-24	64	49	-15	64	49	-15
9 ICH	70	52	-18	70	52	-18	70	52	-18	70	52	-18
6 V	73	58	-20	74	50	-24	69	58	-11	74	50	-24
11 ICH	70	54	-16	70	54	-16	70	54	-16	70	54	-16
13 ICH	72	57	-15	59	57	-2	72	57	-15	59	57	-2
Average			-18			-17			-15			-15
Tidal Flats												
20 BFC	74	57	-17	74	57	-17	69	57	-12	69	57	-12
22	85	50	-35	85	50	-35	85	50	-35	85	50	-35
5 V	72	55	-17	72	55	-17	64	55	-9	64	55	-9
21 PB PC	65	54	-11	65	54	-11	65	54	-11	65	54	-11
9 V	83	54	-29	83	45	-38	79	54	-25	79	45	-34
8 V	88	61	-27	83	47	-36	75	61	-14	70	47	-23
Average			-23			-26			-18			-21
Basins												
16 PA BA	84	70	-14	55	42	-13	84	70	-14	54	42	-12
17	89	70	-19	73	45	-28	89	82	-7	73	45	-28
18	90	82	-8	77	50	-27	90	82	-8	77	50	-27
19 BE BS	89	60	-29	80	50	-30	89	60	-29	80	50	-30
Average			-18			-25			-15			-24

Table 4

[illegible] Plan 3 on Aver[illegible] Dye Concentrations for Dye [illegible]

Bayward from the Protection Barrier (Tidal Cycles 76-[illegible])

Location	High-Water Slack Measurement, ppb — Surface — Base 1967	Plan 3	Difference	Bottom — Base 1967	Plan 3	Difference	Low-Water Slack Measurement, ppb — Surface — Base 1967	Plan 3	Difference	Bottom — Base 1967	Plan 3	Difference
Areas Outside Barrier												
Approach Channel												
[illegible]	41	[illegible]	[illegible]	[illegible]	[illegible]	-18	41	18	[illegible]	41	18	[illegible]
[illegible]	36	[illegible]	[illegible]	36	[illegible]	-21	260	170	-90	240	170	-70
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-19	475	275	-200	300	235	-65
[illegible]	[illegible]	[illegible]	[illegible]	45	48	+3	520	400	[illegible]	400	330	-70
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-3	520	375	-145	300	330	+30
[illegible]	[illegible]	[illegible]	[illegible]	45	25	-20	660	290	-370	325	220	-105
Average			[illegible]			-13			-158			-50
Coney Is Beach												
[illegible]	28	[illegible]	[illegible]	[illegible]	13	-15	67	55	-12	56	[illegible]	-32
[illegible]	[illegible]	11	[illegible]	27	11	-16	51	68	+17	44	17	-27
[illegible]	28	10	[illegible]	27	10	-17	52	42	-10	[illegible]	23	-9
Average			-18			-16			-2			-19
Basins												
[illegible] BA	185	58	-127	50	20	-30	185	58	-127	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	125	-60	36	125	+90	185	11	-175	[illegible]	11	[illegible]
Average			-94			+30			-151			-34
Areas Inside Barrier												
Beach Channel												
[illegible]	145	115	-30	69	82	+13	720	410	-310	510	330	-180
[illegible]	[illegible]	290	-10	102	290	+188	800	460	-340	650	460	-190
[illegible]	[illegible]	210	+15	79	92	+13	790	600	-190	480	375	-105
[illegible]	350	260	[illegible]	290	195	-95	1025	720	-305	920	660	-260
[illegible]	555	325	-230	505	325	-180	1075	900	-175	540	770	-70
[illegible]	840	700	-140	750	540	-210	840	700	-140	750	540	-210
[illegible]	920	690	-230	825	640	-185	920	690	-230	920	640	-280
[illegible]	1000	710	-290	1000	650	-350	1000	650	-350	1000	650	-350
[illegible]	1150	890	-260	1000	760	-240	1150	890	-260	1000	760	-240
Average			-144			-116			-256			-209
[illegible] Channel												
[illegible]	[illegible]	[illegible]	-135	160	135	-25	690	450	-240	480	300	-180
[illegible]	[illegible]	400	-220	460	300	-160	1450	580	-870	620	400	-220
[illegible]	[illegible]	480	-130	580	480	-100	1350	1700	+350	720	400	-320
[illegible]	[illegible]	440	-885	620	440	-180	2015	1010	-1005	765	510	-255
[illegible]	[illegible]	1020	-730	890	650	-240	1395	1020	-375	890	650	-240
Average			-420			-141			-408			-243
Tidal Flats												
[illegible]	650	270	-380	475	27	-205	840	730	-110	650	450	-200
[illegible]	[illegible]	580	-240	820	580	-240	820	580	-240	820	580	-240
[illegible]	[illegible]	465	-215	630	390	-240	820	900	+80	760	610	-150
[illegible]	[illegible]	750	+70	750	555	-195	900	1080	+180	780	550	-230
[illegible]	1300	1080	-220	900	620	-280	1300	1080	-220	900	620	-280
[illegible]	--	1275	--	--	750	--	--	1180	--	--	750	--
Average			-197			-232			[illegible]			-220
Basins												
[illegible] BA BA	[illegible]	[illegible]	[illegible]	590	400	-190	5400	[illegible]	[illegible]	68	400	+332
[illegible]	[illegible]	2025	-125	800	435	[illegible]	[illegible]	4090	[illegible]	79	435	+356
[illegible]	4700	5060	+360	750	610	-140	4700	5060	[illegible]	750	610	-140
[illegible] BB [illegible]	[illegible]	2140	-160	2300	725	[illegible]	1175	2140	+965	1175	725	-450
Average			-586			-568			-614			+25

Table 5

Maximum Surge Elevation in Jamaica Bay

Plan No.	Navigation Opening Width ft	Sill Elevation ft Below msl	Maximum Surge Elevation ft msl	
			November 1950	Standard Project Design
Base, 1967	--	--	8.4	11.2
3	300	33	6.6	4.8
6	110	33	5.0	2.8
7	150	26	5.6	3.3
8	150	23	5.3	2.9
9	200	23	6.0	3.7
10	200	24.3	6.0	3.9

Note: Flooding damage began at el +5.0 ft msl.

Table 6

Maximum Velocities for the Base and Plan Tests

			Maximum Flood, fps (Prototype)						Maximum Ebb, fps (Prototype)					
Traverse	Station	Depth*	Base 1974	Plan A	Plan B	Plan C-1	Plan C-2	Plan C-3	Base 1974	Plan A	Plan B	Plan C-1	Plan C-2	Plan C-3
A	1	S	1.9	1.6	--	1.9	1.7	2.1	2.5	2.9	--	2.4	2.8	2.5
A	2	S	2.0	2.0	--	2.1	1.8	1.9	1.9	2.0	--	1.8	2.1	2.0
A	3	S	2.4	2.5	--	2.4	2.4	2.5	2.2	1.9	--	1.8	1.8	1.7
A	3	M	2.6	2.3	--	2.2	2.4	2.4	1.9	1.7	--	1.7	1.7	1.7
A	4	S	1.4	1.5	--	1.6	1.6	1.4	1.9	2.0	--	2.4	2.1	2.6
F	--	S	2.1	1.7	2.0	2.3	2.1	2.1	1.6	2.7	2.1	2.3	1.6	1.8
G	--	S	2.4	1.7	2.0	2.3	1.9	2.4	1.4	2.9	2.2	2.6	2.3	2.5
C	1	S	2.1	1.9	2.2	2.3	2.6	2.5	1.7	2.0	1.9	1.8	1.8	1.6
C	2	S	1.7	2.0	2.2	2.5	2.5	2.7	1.0	1.7	1.7	1.3	1.4	1.1
C	3	S	2.1	3.1	2.6	2.7	3.4	3.1	1.4	1.6	1.1	1.3	1.1	1.1
C	3	M	2.4	3.4	2.6	2.4	2.8	2.8	1.5	1.5	1.2	1.5	1.3	1.3
C	3	B	1.9	3.0	1.6	1.9	1.5	1.3	1.3	1.0	1.4	1.3	1.1	1.1
C	4	S	1.8	2.0	2.4	2.7	2.7	2.9	1.4	1.5	1.3	1.1	1.5	1.4
C	5	S	1.4	1.5	1.5	2.1	2.3	2.6	1.3	1.4	1.1	1.3	1.5	1.8

* S = surface, M = middepth, and B = bottom.

Table 7

Velocity Maximums for Base Condition (1974)

at Traverses B, D, E, H, and J

Traverse	Station	Depth*	Maximum Flood fps (Prototype)	Maximum Ebb fps (Prototype)
B	1	S	1.6	2.1
B	2	S	2.1	2.0
B	3	S	2.4	1.7
B	3	M	2.3	1.9
B	4	S	1.9	1.7
B	5	S	0.7	1.0
D	1	S	1.2	1.4
D	2	S	1.4	1.1
D	2	M	1.6	1.6
D	3	S	1.6	1.2
D	4	S	0.9	0.3
E	1	S	0.9	1.2
E	2	S	1.6	1.5
E	3	S	1.7	1.0
E	3	M	1.4	1.1
E	4	S	1.2	0.9
E	4	M	1.2	1.0
H	1	S	1.6	1.6
H	2	S	1.8	1.5
H	2	M	1.8	1.5
H	3	S	1.9	1.5
J	1	S	1.2	1.3
J	1	M	1.2	1.4
J	2	S	1.5	1.1
J	3	S	1.2	1.2
J	3	M	1.7	1.2
J	4	S	1.0	1.6

* S = surface, M = middepth, and B = bottom.

Table 8

Tidal Elevations Across the Surge Barrier

Time* hr	Base, 1974 Parkway West	Base, 1974 Parkway East	Base, 1974 West-East = Δh**	Plan C-1 Parkway West	Plan C-1 Parkway East	Plan C-1 West-East = Δh**	Plan C-2 Parkway West	Plan C-2 Parkway East	Plan C-2 West-East = Δh**	Plan C-3 Parkway West	Plan C-3 Parkway East	Plan C-3 West-East = Δh**
0.0	0.8	0.75	--	0.8	0.85	--	0.9	0.9	--	0.9	0.85	--
0.5	0.45	0.5	--	0.45	0.55	-0.1	0.5	0.55	--	0.5	0.5	--
1.0	0.25	0.2	--	0.2	0.3	-0.1	0.3	0.35	--	0.2	0.3	-0.1
1.5	0.2	0.15	--	0.15	0.2	--	0.2	0.2	--	0.2	0.15	--
2.0	0.3	0.2	+0.1	0.25	0.2	--	0.25	0.2	--	0.25	0.25	--
2.5	0.5	0.5	--	0.5	0.5	--	0.5	0.5	--	0.4	0.4	--
3.0	0.9	0.95	--	0.95	0.9	--	0.85	0.85	--	0.85	0.85	--
3.5	1.45	1.5	--	1.55	1.35	+0.2	1.5	1.45	--	1.45	1.4	--
4.0	2.05	2.15	-0.1	2.15	2.0	+0.15	2.15	2.1	--	2.1	2.1	--
4.5	2.7	2.75	--	2.75	2.6	+0.15	2.7	2.7	--	2.75	2.65	+0.1
5.0	3.25	3.3	--	3.3	3.25	--	3.25	3.3	--	3.3	3.25	--
5.5	3.8	3.85	--	3.85	3.8	--	3.8	3.8	--	3.8	3.8	--
6.0	4.33	4.4	--	4.3	4.4	-0.1	4.35	4.35	--	4.3	4.3	--
6.5	4.8	4.75	--	4.7	4.75	--	4.75	4.75	--	4.7	4.7	--
7.0	5.0	5.1	-0.1	5.0	5.1	-0.1	5.1	5.1	--	5.0	5.05	--
7.5	5.2	5.2	--	5.2	5.25	--	5.25	5.3	--	5.2	5.25	--
8.0	5.0	5.1	-0.1	5.05	5.2	-0.15	5.15	5.25	-0.1	5.05	5.1	--
8.5	4.7	4.63	--	4.8	5.0	-0.2	4.9	4.95	--	4.8	4.8	--
9.0	4.3	4.23	--	4.3	4.5	-0.2	4.35	4.45	-0.1	4.3	4.25	--
9.5	3.8	3.8	--	3.75	3.95	-0.2	3.8	3.85	--	3.75	3.75	--
10.0	3.2	3.15	--	3.2	3.3	-0.1	3.2	3.3	-0.1	3.15	3.2	--
10.5	2.7	2.7	--	2.7	2.8	-0.1	2.7	2.8	-0.1	2.65	2.7	--
11.0	2.15	2.1	--	2.2	2.3	-0.1	2.2	2.25	--	2.2	2.15	--
11.5	1.7	1.6	-0.1	1.75	1.7	--	1.75	1.75	--	1.7	1.7	--
12.0	1.2	1.2	--	1.2	1.2	--	1.2	1.35	-0.15	1.2	1.2	--
MTL	2.59	2.59		2.60	2.63		2.62	2.65		2.53	2.58	

* Time is expressed in hours after moon's transit of 74th meridian.
** Δh is only expressed if $\geq \pm 0.1$ ft.

Table 9

Tidal Elevations of Plan C-1 (Phase 5)

	Elevation, ft mlw (Prototype)													
	Sandy Hook		Parkway West		Parkway East		Canarsie		Rosie's Boat		Grassy Bay		Head of Bay	
Time*	Base 1974	Plan C-1	Base 1974	Plan C-1	Base 1974	Plan C-1	Base 1974	Plan C-1	Base 1974	Plan C-1	Base 1974	Plan C-1	Base 1974	Plan C-1
0.0	0.9	0.9	0.8	0.8	0.75	0.85	0.75	0.85	0.8	0.9	0.95	0.95	1.05	1.15
0.5	0.5	0.6	0.45	0.45	0.5	0.55	0.4	0.4	0.45	0.5	0.55	0.6	0.7	0.7
1.0	0.35	0.4	0.25	0.2	0.2	0.3	0.05	0.15	0.2	0.2	0.2	0.35	0.5	0.3
1.5	0.3	0.3	0.2	0.15	0.15	0.2	-0.05	-0.05	0.0	0.0	0.0	0.0	0.25	0.1
2.0	0.5	0.4	0.3	0.25	0.2	0.2	-0.05	0.0	-0.1	0.0	0.0	-0.05	0.15	-0.1
2.5	0.7	0.7	0.5	0.5	0.5	0.5	0.15	0.2	0.3	0.15	0.3	0.1	0.15	0.2
3.0	1.0	1.1	0.9	0.95	0.95	0.9	0.65	0.65	0.7	0.7	0.6	0.45	0.55	0.6
3.5	1.6	1.6	1.45	1.55	1.5	1.35	1.2	1.25	1.25	1.2	1.3	1.1	1.15	1.15
4.0	2.3	2.3	2.05	2.15	2.15	2.0	1.85	1.9	1.9	1.8	2.0	1.8	1.75	1.7
4.5	2.8	2.8	2.7	2.75	2.75	2.6	2.5	2.55	2.6	2.5	2.65	2.65	2.55	2.35
5.0	3.4	3.5	3.25	3.3	3.3	3.25	3.15	3.15	3.2	3.15	3.2	3.05	3.15	3.05
5.5	3.95	4.0	3.8	3.85	3.85	3.8	3.65	3.75	3.8	3.7	3.8	3.7	3.75	3.7
6.0	4.4	4.4	4.35	4.3	4.4	4.4	4.05	4.15	4.3	4.2	4.35	4.05	4.35	4.2
6.5	4.8	4.8	4.8	4.7	4.75	4.75	4.7	4.65	4.8	4.6	4.85	4.6	4.8	4.65
7.0	4.95	5.0	5.0	5.0	5.1	5.1	5.05	5.05	5.1	5.0	5.25	5.05	5.25	5.1
7.5	5.0	5.0	5.2	5.2	5.2	5.25	5.2	5.3	5.3	5.3	5.5	5.4	5.55	5.5
8.0	4.95	4.9	5.0	5.05	5.1	5.2	5.2	5.2	5.25	5.3	5.5	5.3	5.5	5.6
8.5	4.65	4.8	4.7	4.8	4.65	5.0	4.75	5.05	5.0	5.0	5.1	5.05	5.3	5.3
9.0	4.2	4.3	4.3	4.3	4.25	4.5	4.4	4.6	4.6	4.6	4.7	4.65	4.8	4.8
9.5	3.8	3.75	3.8	3.75	3.8	3.95	3.9	4.05	4.0	4.0	4.1	4.05	4.25	4.4
10.0	3.3	3.2	3.2	3.2	3.15	3.3	3.35	3.4	3.45	3.5	3.5	3.6	3.7	3.7
10.5	2.7	2.7	2.7	2.7	2.7	2.8	2.7	2.8	2.9	2.9	3.0	2.8	3.05	3.15
11.0	2.25	2.2	2.15	2.2	2.1	2.3	2.15	2.2	2.4	2.3	2.5	2.35	2.55	2.6
11.5	1.7	1.7	1.7	1.75	1.6	1.7	1.7	1.85	1.8	1.8	2.0	1.85	2.05	2.05
12.0	1.25	1.2	1.2	1.2	1.2	1.2	1.15	1.3	1.3	1.35	1.45	1.45	1.6	1.6
MTL	2.65	2.66	2.59	2.60	2.59	2.63	2.50	2.57	2.61	2.58	2.69	2.59	2.73	2.70

* Time is expressed in hours after moon's transit of 74th meridian.

Table 10

Effects of Plan C-1 on Current Velocities

Station 1 V

Time*	Velocity, fps (Prototype)					
	Surface		Middepth		Bottom	
hr	Base, 1974	Plan C-1	Base, 1974	Plan C-1	Base, 1974	Plan C-1
0.0	-1.1	-1.7	-1.1	-1.6	-1.6	-1.5
0.5	-1.0	-1.2	-1.0	-1.6	-1.0	-0.9
1.0	-1.0	-1.0	-0.1	-1.0	-0.5	-0.9
1.5	0.1	-0.9	0.1	-0.6	0.1	-0.8
2.0	0.1	-0.1	0.2	0.1	0.1	0.1
2.5	0.2	0.4	0.9	0.6	0.8	0.3
3.0	0.6	1.0	1.5	1.2	0.9	0.5
3.5	1.0	1.0	1.7	1.6	1.0	0.9
4.0	1.0	1.0	1.7	1.6	0.9	0.9
4.5	1.1	1.2	1.8	1.8	0.9	0.9
5.0	1.1	1.2	1.8	1.6	1.0	0.6
5.5	1.1	1.5	1.7	1.5	0.9	0.6
6.0	0.9	1.0	1.4	1.2	0.9	0.5
6.5	0.6	1.0	1.1	1.2	0.7	0.5
7.0	0.2	0.5	0.8	0.9	0.5	0.5
7.5	0.1	0.2	0.1	0.2	0.1	0.5
8.0	-0.1	0.1	0.1	0.1	0.1	0.1
8.5	-1.0	-0.9	-0.8	-0.5	0.1	0.1
9.0	-1.2	-1.2	-0.9	-0.9	-0.8	0.1
9.5	-1.6	-1.2	-1.3	-1.2	-1.3	-0.5
10.0	-1.3	-1.6	-1.6	-1.6	-1.6	-1.0
10.5	-1.6	-1.8	-1.8	-2.0	-1.6	-1.0
11.0	-1.6	-2.0	-1.6	-2.0	-1.8	-1.5
11.5	-1.6	-2.0	-1.6	-1.9	-2.0	-1.6
12.0	-1.5	-1.9	-1.6	-1.6	-2.0	-1.8

	Maximum Flood		Maximum Ebb	
	Time hr	Velocity fps	Time hr	Velocity fps
		Surface		
Base, 1974	4.5	1.1	9.5	-1.6
Plan C-1	5.5	1.5	11.0	-2.0
		Middepth		
Base, 1974	4.5	1.8	10.5	-1.8
Plan C-1	4.5	1.8	10.5	-2.0
		Bottom		
Base, 1974	3.5	1.0	11.5	-2.0
Plan C-1	3.5	0.9	12.0	-1.8

* Time is expressed in hours after moon's transit of 74th meridian.

Table 11

Effects of Plan C-1 on Current Velocities

Station 2 V

Time*	Velocity, fps (Prototype)					
	Surface		Middepth		Bottom	
hr	Base, 1974	Plan C-1	Base, 1974	Plan C-1	Base, 1974	Plan C-1
0.0	-1.7	-1.3	-1.6	-1.4	-1.6	-1.2
0.5	-1.3	-1.3	-1.6	-1.1	-1.2	-1.0
1.0	-1.0	-1.0	-0.9	-0.9	-0.7	-0.9
1.5	-0.5	-0.7	0.1	0.2	0.1	0.1
2.0	0.1	-0.1	0.3	0.1	0.3	0.1
2.5	0.9	0.2	1.0	0.7	0.9	0.5
3.0	1.3	1.1	1.6	1.4	1.6	1.0
3.5	1.7	1.6	2.1	1.6	1.6	1.6
4.0	2.0	2.0	2.3	2.0	1.7	1.7
4.5	2.0	2.1	2.2	2.1	1.6	1.7
5.0	2.1	2.3	2.0	2.0	1.6	1.6
5.5	1.6	2.0	2.0	1.8	1.5	1.6
6.0	1.6	1.7	1.6	1.7	1.3	1.5
6.5	1.1	1.0	1.2	1.5	1.0	1.2
7.0	0.3	0.9	0.9	1.0	0.9	0.9
7.5	0.1	0.3	0.2	0.5	0.5	0.6
8.0	-0.3	0.1	0.1	0.1	0.1	0.1
8.5	-0.9	-0.4	-0.9	-0.6	0.1	0.1
9.0	-1.2	-1.0	-1.2	-0.9	-0.9	-0.9
9.5	-1.6	-1.1	-1.5	-1.6	-1.4	-1.4
10.0	-1.9	-1.2	-1.7	-1.6	-1.6	-1.5
10.5	-2.0	-1.5	-1.8	-1.6	-1.8	-1.5
11.0	-2.1	-1.6	-2.0	-1.6	-2.1	-1.4
11.5	-2.0	-1.6	-2.0	-1.6	-2.1	-1.4
12.0	-1.8	-1.5	-2.0	-1.6	-1.9	-1.4

	Maximum Flood		Maximum Ebb	
	Time hr	Velocity fps	Time hr	Velocity fps
Surface				
Base, 1974	5.0	2.1	11.0	-2.1
Plan C-1	5.0	2.3	11.0	-1.6
Middepth				
Base, 1974	4.0	2.3	11.0	-2.0
Plan C-1	4.5	2.1	9.5	-1.6
Bottom				
Base, 1974	4.0	1.7	11.0	-2.1
Plan C-1	4.0	1.7	10.0	-1.5

* Time is expressed in hours after moon's transit of 74th meridian.

Table 12

Effects of Plan C-1 on Current Velocities

Station 3 V

Time* hr	Velocity, fps (Prototype)					
	Surface		Middepth		Bottom	
	Base, 1974	Plan C-1	Base, 1974	Plan C-1	Base, 1974	Plan C-1
0.0	-1.3	-1.6	-1.3	-1.5	-0.9	-1.3
0.5	-1.3	-1.5	-1.0	-1.6	-0.9	-1.4
1.0	-1.3	-1.2	-0.4	-1.3	-0.3	-0.8
1.5	-0.6	-0.8	-0.1	-0.7	0.1	-0.6
2.0	0.1	0.1	0.0	0.1	0.9	0.1
2.5	1.1	0.6	1.1	0.3	0.9	0.6
3.0	1.5	1.2	1.3	1.0	1.2	1.2
3.5	1.5	1.6	1.3	1.5	1.3	1.6
4.0	1.6	1.6	1.5	1.8	1.3	1.8
4.5	1.7	1.8	1.6	1.8	1.5	1.7
5.0	1.6	1.4	1.7	1.7	1.2	1.5
5.5	1.5	1.4	1.6	1.4	1.3	1.5
6.0	1.2	1.3	1.2	1.3	1.0	1.3
6.5	0.9	0.9	0.8	1.1	0.8	1.1
7.0	0.8	0.8	0.5	1.0	0.9	0.8
7.5	0.1	0.1	0.2	0.3	0.4	0.5
8.0	-0.3	0.1	0.1	0.1	0.1	0.3
8.5	-1.1	-0.6	-0.7	-0.4	-0.4	-0.1
9.0	-1.3	-1.1	-1.1	-1.2	-0.8	-0.8
9.5	-1.5	-1.1	-1.4	-1.2	-1.0	-1.0
10.0	-1.5	-1.3	-1.3	-1.4	-1.0	-1.4
10.5	-1.6	-1.4	-1.3	-1.5	-1.2	-1.4
11.0	-1.7	-1.5	-1.5	-1.5	-1.3	-1.5
11.5	-1.6	-1.5	-1.4	-1.6	-1.3	-1.5
12.0	-1.4	-1.6	-1.4	-1.8	-1.2	-1.4

	Maximum Flood		Maximum Ebb	
	Time hr	Velocity fps	Time hr	Velocity fps
		Surface		
Base, 1974	4.5	1.7	11.0	-1.7
Plan C-1	4.5	1.8	0.0	-1.6
		Middepth		
Base, 1974	5.0	1.7	11.0	-1.5
Plan C-1	4.0	1.8	12.0	-1.8
		Bottom		
Base, 1974	4.5	1.5	11.0	-1.3
Plan C-1	4.0	1.8	11.0	-1.5

* Time is expressed in hours after moon's transit of 74th meridian.

Table 13

Effects of Plan C-1 on Current Velocities

Station 4 V

Time* hr	Velocity, fps (Prototype)			
	Surface		Bottom	
	Base, 1974	Plan C-1	Base, 1974	Plan C-1
0.0	-0.9	-1.3	-1.1	-1.0
0.5	-0.5	-1.3	-1.1	-1.0
1.0	0.1	-1.1	-1.1	-0.9
1.5	0.1	-0.6	-0.9	-0.6
2.0	0.9	0.3	0.1	-0.1
2.5	1.6	0.6	0.8	0.5
3.0	1.8	1.3	1.3	0.7
3.5	2.0	1.8	1.7	1.4
4.0	2.1	2.1	1.8	1.6
4.5	1.7	2.1	1.7	1.7
5.0	1.6	1.7	1.7	1.5
5.5	1.2	1.6	1.3	1.4
6.0	1.1	1.3	1.2	1.2
6.5	0.8	1.1	1.1	1.1
7.0	0.6	1.2	0.9	0.8
7.5	0.1	0.6	0.1	0.6
8.0	-0.3	0.3	0.1	0.4
8.5	-0.4	-0.5	-0.3	0.3
9.0	-0.9	-0.7	-0.9	0.3
9.5	-1.0	-0.8	-0.9	-0.5
10.0	-1.1	-0.9	-1.1	-0.8
10.5	-1.1	-1.1	-1.2	-1.0
11.0	-1.1	-1.3	-1.4	-1.2
11.5	-1.2	-1.7	-1.3	-1.1
12.0	-1.1	-1.6	-1.2	-1.0

	Maximum Flood		Maximum Ebb	
	Time hr	Velocity fps	Time hr	Velocity fps
Surface				
Base, 1974	4.0	2.1	11.5	-1.2
Plan C-1	4.0	2.1	11.5	-1.7
Bottom				
Base, 1974	4.0	1.8	11.0	-1.4
Plan C-1	4.5	1.7	11.0	-1.2

* Time is expressed in hours after moon's transit of 74th meridian.

Table 14

Effects of Plan C-1 on Current Velocities

Station 5 V

Time* hr	Surface Velocity, fps (Prototype) Base, 1974	Plan C-1
0.0	-0.7	-0.4
0.5	-0.5	-0.3
1.0	0.1	0.1
1.5	0.1	0.1
2.0	0.4	0.6
2.5	1.3	0.6
3.0	1.3	0.9
3.5	1.2	0.9
4.0	1.3	0.7
4.5	1.2	0.6
5.0	1.1	0.6
5.5	0.9	0.7
6.0	0.7	0.8
6.5	0.5	0.5
7.0	0.1	0.3
7.5	0.1	0.1
8.0	0.1	0.1
8.5	-0.1	-0.4
9.0	-0.7	-0.7
9.5	-0.9	-0.7
10.5	-0.9	-0.7
10.5	-0.9	-0.9
11.5	-0.9	-0.7
11.5	-0.9	-0.8
12.0	-0.9	-0.6

	Maximum Flood Time hr	Maximum Flood Velocity fps	Maximum Ebb Time hr	Maximum Ebb Velocity fps
		Surface		
Base, 1974	2.5	1.3	9.5	-0.9
Plan C-1	3.0	0.9	10.5	-0.9

* Time is expressed in hours after moon's transit of 74th meridian.

Table 15

Effects of Plan C-1 on Current Velocities

Station 6 V

Time* hr	Velocity, fps (Prototype) Surface Base, 1974	Surface Plan C-1	Bottom Base, 1974	Bottom Plan C-1
0.0	-1.0	-0.8	-0.7	-0.6
0.5	-0.9	-0.8	-1.0	-0.6
1.0	-0.6	-0.8	-0.8	-0.8
1.5	-0.5	-0.5	-0.6	-0.6
2.0	-0.3	-0.1	-0.2	-0.4
2.5	0.1	0.1	0.1	0.2
3.0	0.3	0.6	0.5	0.3
3.5	0.8	0.7	0.5	0.4
4.0	0.9	0.8	0.8	0.5
4.5	1.0	1.0	0.8	0.8
5.0	0.7	1.0	1.0	1.0
5.5	0.8	1.0	0.9	0.8
6.0	1.0	1.0	1.4	0.8
6.5	1.0	0.8	1.3	0.6
7.0	0.9	0.8	1.2	0.8
7.5	0.5	0.8	0.8	0.4
8.0	0.6	0.7	0.5	0.4
8.5	0.1	0.3	0.3	0.0
9.0	-0.1	0.0	0.0	-0.4
9.5	-0.5	-0.5	-0.2	-0.4
10.0	-0.6	-0.3	-0.4	-0.4
10.5	-0.9	-0.8	-0.6	-0.6
11.0	-0.7	-0.6	-0.8	-0.6
11.5	-0.8	-0.7	-0.5	-0.6
12.0	-1.0	-0.8	-1.0	-0.8

	Maximum Flood Time hr	Maximum Flood Velocity fps	Maximum Ebb Time hr	Maximum Ebb Velocity fps
Surface				
Base, 1974	4.5	1.0	0.0	-1.0
Plan C-1	4.5	1.0	0.0	-0.8
Bottom				
Base, 1974	6.0	1.4	0.5	-1.0
Plan C-1	5.0	1.0	1.0	-0.8

* Time is expressed in hours after moon's transit of 74th meridian.

Table 16

Effects of Plan C-1 on Current Velocities

Station 7 V

Time* hr	Surface Velocity, fps (Prototype) Base, 1974	Plan C-1
0.0	-0.7	-0.5
0.5	-0.6	-0.4
1.6	-0.7	-0.3
1.0	-0.3	
2.0	-0.2	-0.3
2.5	0.0	0.0
3.0	0.0	0.5
3.5	0.2	
4.0	0.3	0.5
4.5	0.7	
5.0	0.4	0.6
5.5	0.5	
6.5	0.5	0.6
6.5	0.4	
7.0	0.3	0.6
7.5	0.3	
8.0	0.2	0.5
8.5	0.0	0.0
9.0	-0.2	
9.5	-0.4	-0.2
10.0	-0.4	
10.5	-0.6	-0.3
11.0	-0.6	-0.5
11.5	-0.4	-0.6
12.0	-0.3	-0.5

	Maximum Flood		Maximum Ebb	
	Time hr	Velocity fps	Time hr	Velocity fps
		Surface		
Base, 1974	4.5	0.7	0.0	-0.7
Plan C-1	7.0	0.6	11.5	-0.6

* Time is expressed in hours after moon's transit of 74th meridian.

Table 17

Effects of Plan C-1 on Current Velocities

Station 8 V

Time* hr	Surface Velocity, fps (Prototype) Base, 1974	Plan C-1
0.0	-0.2	-0.2
0.5	0.0	-0.1
1.0	0.0	
1.5	-0.1	0.0
2.0	0.0	
2.5	0.1	0.4
3.0	0.4	
3.5	0.4	0.4
4.0	0.2	
4.5	0.0	0.1
5.0	0.0	0.0
5.5	0.0	0.0
6.0	-0.1	0.0
6.5	-0.2	0.0
7.0	-0.2	0.0
7.5	-0.2	-0.2
8.0	-0.3	
8.5	-0.4	-0.3
9.0	-0.3	
9.5	-0.3	-0.3
10.0	-0.2	
10.5	-0.2	-0.3
11.0	-0.2	
11.5	-0.2	-0.2
12.0	-0.2	-0.2

	Maximum Flood		Maximum Ebb	
	Time hr	Velocity fps	Time hr	Velocity fps
		Surface		
Base, 1974	3.0	0.4	8.5	-0.4
Plan C-1	3.5	0.4	8.5	-0.3

* Time is expressed in hours after moon's transit of 74th meridian.

Table 18

Effects of Plan C-1 on Current Velocities

Station 9 V

Time* hr	Surface Velocity, fps (Prototype) Base, 1974	Plan C-1
0.0	0.0	0.0
0.5	0.0	-0.2
1.0	-0.1	
1.5	0.0	0.0
2.0	0.2	
2.5	0.3	0.2
3.0	0.4	0.4
3.5	0.5	
4.0	0.5	0.5
4.5	0.2	
5.0	0.3	0.4
5.5	0.3	0.4
6.0	0.3	0.4
6.5	0.2	
7.0	0.2	0.3
7.5	0.1	0.3
8.0	0.0	0.3
8.5	-0.1	0.0
9.0	-0.2	0.0
9.5	-0.2	0.0
10.0	-0.2	0.0
10.5	-0.1	0.0
11.0	0.0	0.0
11.5	0.0	0.0
12.5	-0.2	0.0

	Maximum Flood		Maximum Ebb	
	Time hr	Velocity fps	Time hr	Velocity fps
		Surface		
Base, 1974	3.5	0.5	9.5	-0.2
Plan C-1	4.0	0.5	0.5	-0.2

* Time is expressed in hours after moon's transit of 74th meridian.

Table 19

Effects of Plan C-1 on Current Velocities

Station 1 OC

Time* hr	Velocity, fps (Prototype) Surface Base, 1974	Surface Plan C-1	Bottom Base, 1974	Bottom Plan C-1
0.0	-2.9	-2.7	-2.5	-2.3
0.5	-2.4	-2.5	-2.2	-1.8
1.0	-1.8	-1.9	-1.5	-1.6
1.5	-0.7	-1.0	-0.9	-1.7
2.0	0.1	0.4	0.1	-1.0
2.5	0.9	1.0	0.8	0.8
3.0	0.9	1.2	1.0	1.3
3.5	-1.0	1.2	-0.9	1.0
4.0	-1.4	-1.6	-1.1	-1.7
4.5	-1.4	-1.5	-1.3	-1.4
5.0	-1.5	-1.4	-1.2	-1.2
5.5	-1.3	-1.1	-0.8	-1.1
6.0	-0.9	-1.2	-0.8	-1.0
6.5	-1.2	-0.6	-0.1	-0.6
7.0	-0.8	-0.3	-0.4	-0.9
7.5	-0.5	-0.6	-0.6	-0.6
8.0	-0.7	-0.3	-1.4	-0.3
8.5	-2.4	-2.2	-2.1	-1.8
9.0	-2.6	-2.2	-2.7	-2.4
9.5	-3.0	-2.3	-2.9	-2.5
10.0	-2.7	-2.7	-2.3	-2.5
10.5	-2.6	-2.3	-2.3	-2.3
11.0	-2.7	-2.7	-2.3	-2.3
11.5	-3.1	-2.6	-2.4	-2.3
12.0	-3.1	-2.7	-2.6	-2.4

	Maximum Flood Time hr	Maximum Flood Velocity fps	Maximum Ebb Time hr	Maximum Ebb Velocity fps
		Surface		
Base, 1974	2.5	0.9	11.5	-3.1
Plan C-1	3.0	1.2	0.0	-2.7
		Bottom		
Base, 1974	3.0	1.0	9.5	-2.9
Plan C-1	3.0	1.3	9.5	-2.5

* Time is expressed in hours after moon's transit of 74th meridian.

Table 20

Effects of Plan C-1 on Current Velocities

Station 3 OC

Time* hr	Velocity, fps (Prototype) Surface Base, 1974	Surface Plan C-1	Bottom Base, 1974	Bottom Plan C-1
0.0	-1.4	-1.5	-1.4	-1.5
0.5	-1.0	-1.3	-0.9	-1.3
1.0	-0.5	-1.0	-0.6	-1.1
1.5	0.1	-0.5	0.1	-0.8
2.0	0.3	0.3	0.6	0.3
2.5	1.2	1.0	1.3	0.5
3.0	1.3	1.3	1.5	1.1
3.5	1.4	1.8	1.6	1.7
4.0	1.8	1.8	1.7	1.7
4.5	1.8	1.7	1.7	1.7
5.0	1.5	1.7	1.7	1.5
5.5	1.2	1.5	1.5	1.7
6.0	0.4	1.1	1.0	1.4
6.5	0.1	0.9	0.1	1.1
7.0	0.2	0.9	0.1	0.6
7.5	0.3	0.8	0.1	0.5
8.0	-0.1	0.4	0.1	0.3
8.5	-0.7	-0.5	-0.6	-0.6
9.0	-1.2	-1.0	-0.9	-1.0
9.5	-1.5	-1.1	-0.9	-1.1
10.0	-1.6	-1.1	-1.2	-1.1
10.5	-1.4	-1.5	-1.2	-1.2
11.0	-1.6	-1.6	-1.4	-1.2
11.5	-1.6	-1.6	-1.5	-1.3
12.0	-1.6	-1.5	-1.6	-1.4

	Maximum Flood Time hr	Maximum Flood Velocity fps	Maximum Ebb Time hr	Maximum Ebb Velocity fps
Surface				
Base, 1974	4.0	1.8	10.0	-1.6
Plan C-1	3.5	1.8	11.0	-1.6
Bottom				
Base, 1974	4.0	1.7	12.0	-1.6
Plan C-1	4.0	1.7	0.0	-1.5

* Time is expressed in hours after moon's transit of 74th meridian.

Table 21

Effects of Plan C-1 on Current Velocities

Station 0 BCH

Time* hr	Velocity, fps (Prototype): Surface, Base, 1974	Surface, Plan C-1	Bottom, Base, 1974	Bottom, Plan C-1
0.0	-0.7	-0.8	-0.7	-0.4
0.5	-0.7	-0.8	-0.7	-0.6
1.0	-0.5	-0.6	-0.1	-0.3
1.5	0.1	-0.3	0.1	0.1
2.0	0.1	0.1	0.2	0.3
2.5	0.5	0.3	0.6	0.3
3.0	1.0	0.5	1.0	0.4
3.5	1.2	1.2	1.1	0.8
4.0	1.4	1.3	1.3	0.8
4.5	1.3	1.2	1.2	0.8
5.0	1.3	0.9	1.4	0.8
5.5	1.4	1.0	1.3	0.8
6.0	1.3	0.8	1.1	0.8
6.5	1.0	0.8	0.9	0.8
7.0	0.7	0.4	0.7	0.3
7.5	0.3	0.1	0.1	0.3
8.0	0.1	-0.3	0.1	0.1
8.5	-0.1	-0.3	-0.1	-0.3
9.0	-0.6	-0.4	-0.5	-0.5
9.5	-0.6	-0.4	-0.7	-0.7
10.0	-0.9	-0.6	-0.8	-0.6
10.5	-1.1	-0.6	-0.8	-0.4
11.0	-0.9	-0.6	-0.9	-0.6
11.5	-0.9	-0.8	-0.9	-0.6
12.0	-0.9	-0.6	-1.0	-0.5

	Maximum Flood: Time hr	Maximum Flood: Velocity fps	Maximum Ebb: Time hr	Maximum Ebb: Velocity fps
Surface				
Base, 1974	5.5	1.4	10.5	-1.1
Plan C-1	4.0	1.3	0.0	-0.8
Bottom				
Base, 1974	5.0	1.4	12.0	-1.0
Plan C-1	3.5	0.8	9.5	-0.7

* Time is expressed in hours after moon's transit of 74th meridian.

Table 22

Effects of Plan C-1 on Current Velocities

Station 1 BCH

Time* hr	Velocity, fps (Prototype) Surface: Base, 1974	Surface: Plan C-1	Bottom: Base, 1974	Bottom: Plan C-1
0.0	-1.2	-0.9	-1.0	-0.8
0.5	-0.9	-0.9	-0.9	-0.7
1.0	-0.8	-0.8	0.0	-0.7
1.5	-0.3	-0.3	0.1	-0.7
2.0	0.1	0.1	0.2	0.1
2.5	0.8	0.3	0.9	0.1
3.0	0.9	0.9	1.2	0.9
3.5	1.0	1.0	1.5	1.0
4.0	1.2	1.3	1.6	1.1
4.5	1.1	1.1	1.4	1.5
5.0	1.0	1.0	1.4	1.5
5.5	1.0	0.9	1.2	1.4
6.0	0.9	0.8	0.9	1.1
6.5	0.7	0.7	0.7	0.9
7.0	0.5	0.5	0.3	0.6
7.5	0.1	0.1	0.1	0.1
8.0	0.1	0.1	0.1	0.1
8.5	-0.3	0.1	0.1	0.1
9.0	-0.9	-0.7	-0.4	-0.8
9.5	-0.9	-0.7	-0.6	-0.8
10.0	-1.0	-0.9	-0.6	-0.8
10.5	-1.3	-1.0	-0.9	-0.9
11.0	-1.2	-1.0	-0.9	-0.9
11.5	-1.3	-0.9	-0.9	-0.9
12.0	-1.3	-0.9	-1.0	-1.0

	Maximum Flood Time hr	Maximum Flood Velocity fps	Maximum Ebb Time hr	Maximum Ebb Velocity fps
		Surface		
Base, 1974	4.0	1.2	10.5	-1.3
Plan C-1	4.0	1.3	10.5	-1.0
		Bottom		
Base, 1974	4.0	1.6	0.0	-1.0
Plan C-1	4.5	1.5	12.0	-1.0

* Time is expressed in hours after moon's transit of 74th meridian.

Table 23

Effects of Plan C-1 on Current Velocities

Station 14 V

Time* hr	Velocity, fps (Prototype) Surface Base, 1974	Surface Plan C-1	Bottom Base, 1974	Bottom Plan C-1
0.0	-1.3	-1.7	-1.2	-0.3
0.5	-1.1	-1.3	-0.8	0.1
1.0	-0.5	-0.8	-0.3	-0.3
1.5	0.1	-0.3	0.1	-0.3
2.0	0.4	0.1	0.8	0.1
2.5	0.8	0.6	1.3	0.6
3.0	1.5	1.0	1.9	0.7
3.5	2.2	1.0	2.1	1.4
4.0	2.3	1.9	2.2	1.7
4.5	2.6	2.0	2.4	1.6
5.0	2.5	2.2	2.2	1.5
5.5	2.2	2.1	2.0	1.3
6.0	2.0	1.9	1.4	1.4
6.5	1.4	1.3	1.3	1.3
7.0	1.0	1.2	1.0	0.9
7.5	0.2	0.4	0.3	0.5
8.0	-0.1	0.1	0.1	0.1
8.5	-0.5	-0.5	-0.5	-0.5
9.0	-0.8	-1.3	-0.8	-0.3
9.5	-1.3	-1.3	-1.0	-0.3
10.0	-1.4	-1.5	-1.3	0.0
10.5	-1.5	-1.9	-1.3	-0.3
11.0	-1.7	-2.0	-1.5	-0.4
11.5	-1.7	-2.0	-1.3	-0.4
12.0	-1.5	-2.0	-1.3	-0.4

	Maximum Flood Time hr	Maximum Flood Velocity fps	Maximum Ebb Time hr	Maximum Ebb Velocity fps
		Surface		
Base, 1974	4.5	2.6	11.0	-1.7
Plan C-1	5.0	2.2	11.5	-2.0
		Bottom		
Base, 1974	4.5	2.4	11.0	-1.5
Plan C-1	4.0	1.7	8.5	-0.5

* Time is expressed in hours after moon's transit of 74th meridian.

Table 24

Effects of Plan C-1 on Current Velocities

Station 15 V

Time* hr	Velocity, fps (Prototype)			
	Surface		Bottom	
	Base, 1974	Plan C-1	Base, 1974	Plan C-1
0.0	-1.3	-1.9	-1.3	-1.0
0.5	-1.0	-1.6	-0.9	-0.9
1.0	-0.5	-1.2	-0.3	-0.4
1.5	-0.1	-0.5	0.1	-0.1
2.0	0.1	0.1	0.4	0.1
2.5	1.1	0.6	1.1	0.3
3.0	1.5	1.0	1.7	0.8
3.5	2.0	1.6	1.9	1.2
4.0	2.4	2.0	2.0	1.5
4.5	2.4	2.0	2.1	1.4
5.0	2.5	2.1	1.9	1.5
5.5	2.3	2.0	1.9	1.4
6.0	2.0	1.7	1.4	1.3
6.5	1.4	1.4	1.3	1.3
7.0	1.1	1.0	1.0	1.0
7.5	0.3	0.2	0.4	0.5
8.0	0.1	0.1	0.1	0.1
8.5	-0.5	-0.8	-0.6	-0.4
9.0	-1.2	-1.3	-0.8	-0.6
9.5	-1.3	-1.5	-1.2	-0.8
10.0	-1.5	-1.8	-1.4	-1.0
10.5	-1.5	-2.0	-1.4	-1.1
11.0	-1.7	-2.2	-1.3	-1.2
11.5	-1.7	-2.2	-1.6	-1.0
12.0	-1.5	-2.0	-1.5	-1.2

	Maximum Flood		Maximum Ebb	
	Time hr	Velocity fps	Time hr	Velocity fps
		Surface		
Base, 1974	5.0	2.5	11.0	-1.7
Plan C-1	5.0	2.1	11.0	-2.2
		Bottom		
Base, 1974	4.5	2.1	11.5	-1.6
Plan C-1	4.0	1.5	11.0	-1.2

* Time is expressed in hours after moon's transit of 74th meridian.

Table 25

Effects of Plan C-1 on Current Velocities

Station 16 V

Time* hr	Velocity, fps (Prototype) Surface Base, 1974	Surface Plan C-1	Bottom Base, 1974	Bottom Plan C-1
0.0	-1.0	-0.7	-1.3	-0.5
0.5	-0.8	-0.5	-0.8	-0.5
1.0	-0.5	-0.4	-0.1	0.1
1.5	0.1	-0.1	0.1	0.1
2.0	0.3	0.1	0.4	0.2
2.5	0.1	1.0	1.2	0.2
3.0	1.8	1.9	1.3	0.3
3.5	2.4	2.6	2.1	0.8
4.0	2.4	2.8	2.1	0.8
4.5	2.5	2.9	2.2	0.7
5.0	2.7	3.1	2.1	1.0
5.5	2.5	3.1	2.0	0.9
6.0	2.0	2.7	2.0	0.7
6.5	1.6	2.3	1.3	0.7
7.0	1.1	1.6	1.1	0.4
7.5	0.4	0.6	0.4	0.1
8.0	0.1	0.2	0.1	0.1
8.5	-0.5	-0.4	-0.2	-0.3
9.0	-0.8	-0.5	-0.4	-0.5
9.5	-1.2	-0.7	-0.8	-0.7
10.0	-1.3	-0.7	-1.2	-0.8
10.5	-1.2	-0.7	-1.4	-0.8
11.0	-1.3	-0.8	-1.3	-0.5
11.5	-1.3	-0.8	-1.4	-0.8
12.0	-1.3	-0.9	-1.4	-0.7

	Maximum Flood Time hr	Maximum Flood Velocity fps	Maximum Ebb Time hr	Maximum Ebb Velocity fps
		Surface		
Base, 1974	5.0	2.7	10.0	-1.3
Plan C-1	5.0	3.1	12.0	-0.9
		Bottom		
Base, 1974	4.5	2.2	10.5	-1.4
Plan C-1	5.0	1.0	10.0	-0.8

* Time is expressed in hours after moon's transit of 74th meridian.

Table 26

Effects of Plan C-1 on Current Velocities

Station 17 V

Time* hr	Velocity, fps (Prototype)			
	Surface		Bottom	
	Base, 1974	Plan C-1	Base, 1974	Plan C-1
0.0	-1.0	-0.8	-1.2	-0.8
0.5	-0.6	-0.6	-0.8	-0.6
1.0	-0.5	-0.4	-0.3	-0.5
1.5	-0.1	0.1	0.1	-0.1
2.0	0.1	0.1	0.3	0.2
2.5	0.9	0.7	0.6	0.2
3.0	1.6	1.4	1.2	0.5
3.5	2.2	2.0	1.8	0.3
4.0	2.6	2.3	1.8	0.5
4.5	2.6	2.4	2.2	1.2
5.0	2.7	2.6	2.1	0.6
5.5	2.4	2.6	1.8	1.2
6.0	2.0	2.6	1.8	0.6
6.5	1.5	2.0	1.5	0.5
7.0	1.2	1.3	1.0	0.5
7.5	0.4	0.6	0.5	0.5
8.0	0.1	0.2	0.1	0.1
8.5	-0.3	-0.5	-0.3	-0.4
9.0	-0.7	-0.5	-0.5	-0.6
9.5	-0.7	-0.5	-0.8	-0.4
10.0	-0.8	-0.8	-1.1	-0.7
10.5	-1.3	-0.9	-1.3	-0.7
11.0	-0.9	-0.9	-1.3	-0.7
11.5	-1.0	-1.0	-1.5	-1.0
12.0	-1.0	-0.9	-1.3	-1.0

	Maximum Flood		Maximum Ebb	
	Time hr	Velocity fps	Time hr	Velocity fps
		Surface		
Base, 1974	5.0	2.7	10.5	-1.3
Plan C-1	5.0	2.6	11.5	-1.0
		Bottom		
Base, 1974	4.5	2.2	11.5	-1.5
Plan C-1	4.5	1.2	11.5	-1.0

* Time is expressed in hours after moon's transit of 74th meridian.

Table 27

Effects of Plan C-1 on Current Velocities

Station 4 BCH

Time*	Velocity, fps (Prototype)			
	Surface		Bottom	
hr	Base, 1974	Plan C-1	Base, 1974	Plan C-1
0.0	-0.9	-1.3	-0.7	-0.8
0.5	-0.7	-1.0	-0.5	-0.7
1.0	-0.5	-1.0	-0.5	-0.7
1.5	-0.4	-0.8	0.1	-0.5
2.0	-0.1	-0.3	0.1	-0.2
2.5	0.7	0.0	0.7	0.0
3.0	1.1	0.5	0.9	0.4
3.5	1.2	0.5	0.9	0.4
4.0	1.3	1.0	0.9	0.8
4.5	1.3	1.0	0.9	0.8
5.0	1.1	1.3	0.9	1.0
5.5	1.1	1.3	0.9	1.0
6.0	0.9	1.3	0.6	1.0
6.5	0.7	0.8	0.7	1.3
7.0	0.5	0.7	0.4	0.8
7.5	0.3	0.8	0.1	0.7
8.0	0.1	0.5	0.1	0.6
8.5	-0.3	0.1	-0.1	0.0
9.0	-0.5	-0.6	-0.4	-0.1
9.5	-0.5	-0.5	-0.6	-0.3
10.0	-0.7	-0.7	-0.6	-0.6
10.5	-0.6	-0.8	-0.7	-0.5
11.0	-0.9	-0.8	-0.8	-0.5
11.5	-0.6	-1.0	-0.8	-0.7
12.0	-0.6	-1.3	-0.7	-0.5

	Maximum Flood		Maximum Ebb	
	Time hr	Velocity fps	Time hr	Velocity fps
		Surface		
Base, 1974	4.0	1.3	0.0	-0.9
Plan C-1	5.0	1.3	0.0	-1.3
		Bottom		
Base, 1974	3.0	0.9	11.0	-0.8
Plan C-1	6.5	1.3	0.0	-0.8

* Time is expressed in hours after moon's transit of 74th meridian.

Table 28

Effects of Plan C-1 on Current Velocities

Station 7 ICH

Time* hr	Velocity, fps (Prototype)			
	Surface		Bottom	
	Base, 1974	Plan C-1	Base, 1974	Plan C-1
0.0	-0.5	0.3	-0.5	-0.5
0.5	-0.3	-0.1	0.2	0.3
1.0	0.2	-0.1	0.2	0.3
1.5	0.2	0.3	0.2	0.3
2.0	0.2	0.3	0.2	0.3
2.5	0.2	0.3	0.2	0.3
3.0	0.3	0.5	0.2	0.3
3.5	0.5	0.9	0.9	0.6
4.0	0.9	1.2	0.9	0.8
4.5	0.9	0.9	1.3	1.2
5.0	0.9	0.9	1.3	0.9
5.5	0.9	0.9	0.7	0.5
6.0	0.5	0.7	0.8	0.3
6.5	0.2	0.7	0.5	-0.1
7.0	0.2	0.3	0.2	0.3
7.5	0.2	0.3	0.2	0.3
8.0	-0.1	0.3	-0.2	0.3
8.5	0.2	0.3	0.2	-0.1
9.0	0.2	0.3	0.2	-0.9
9.5	-0.3	0.3	-0.1	-0.9
10.0	-0.5	0.3	-0.6	-0.9
10.5	-0.5	0.3	-0.5	-0.8
11.0	-0.3	0.3	-0.4	-0.6
11.5	0.1	0.3	-0.5	-0.5
12.0	-0.2	0.3	-0.1	-0.1

	Maximum Flood		Maximum Ebb	
	Time hr	Velocity fps	Time hr	Velocity fps
		Surface		
Base, 1974	4.0	0.9	0.0	-0.5
Plan C-1	4.0	1.2	0.5	-0.1
		Bottom		
Base, 1974	4.5	1.3	10.0	-0.6
Plan C-1	4.5	1.2	9.0	-0.9

* Time is expressed in hours after moon's transit of 74th meridian.

Table 29

Effects of Plan C-1 on Current Velocities

Station 9 ICH

Time* hr	Velocity, fps (Prototype): Surface: Base, 1974	Surface: Plan C-1	Bottom: Base, 1974	Bottom: Plan C-1
0.0	-0.4	-0.6	-0.6	-0.4
0.5	-0.5	-0.6	-0.4	-0.5
1.0	-0.6	-0.6	-0.4	-0.5
1.5	-0.4	-0.7	-0.2	-0.4
2.0	-0.4	-0.3	-0.3	-0.3
2.5	-0.2	-0.1	0.0	0.0
3.0	0.2	0.0	0.1	0.0
3.5	0.5	0.3	0.2	0.3
4.0	0.4	0.3	0.5	0.6
4.5	0.4	0.4	0.4	0.4
5.0	0.4	0.4	0.4	0.4
5.5	0.4	0.4	0.3	0.4
6.0	0.4	0.4	0.3	0.4
6.5	0.4	0.4	0.1	0.3
7.0	0.3	0.4	0.4	0.3
7.5	0.1	0.0	0.1	0.3
8.0	-0.3	-0.3	0.0	-0.2
8.5	-0.3	-0.3	-0.2	-0.3
9.0	-0.4	-0.3	-0.1	-0.3
9.5	-0.6	-0.3	-0.2	-0.2
10.0	-0.4	-0.4	-0.3	-0.3
10.5	-0.5	-0.4	-0.2	-0.4
11.0	-0.4	-0.6	-0.4	-0.5
11.5	-0.6	-0.4	-0.5	-0.4
12.0	-0.5	-0.6	-0.6	-0.6

	Maximum Flood: Time hr	Maximum Flood: Velocity fps	Maximum Ebb: Time hr	Maximum Ebb: Velocity fps
Surface				
Base, 1974	3.5	0.5	1.0	-0.6
Plan C-1	7.0	0.4	1.5	-0.7
Bottom				
Base, 1974	4.0	0.5	0.0	-0.6
Plan C-1	4.0	0.6	12.0	-0.6

* Time is expressed in hours after moon's transit of 74th meridian.

Table 30

Effects of Plan C-1 on Current Velocities

Station 11 ICH

Time*	Velocity, fps (Prototype)			
	Surface		Bottom	
hr	Base, 1974	Plan C-1	Base, 1974	Plan C-1
0.0	-0.7	-0.5	-0.5	-0.8
0.5	-0.6	-0.6	-0.3	-0.5
1.0	-0.6	-0.7	-0.5	-0.5
1.5	-0.5	-0.4	-0.4	-0.4
2.0	-0.1	-0.3	-0.2	-0.2
2.5	0.0	0.2	0.1	0.1
3.0	0.2	0.3	0.3	0.3
3.5	0.3	0.4	0.4	0.4
4.0	0.4	0.5	0.6	0.4
4.5	0.7	0.5	0.5	0.5
5.0	0.5	0.5	0.5	0.5
5.5	0.4	0.7	0.5	0.5
6.0	0.5	0.4	0.6	0.6
6.5	0.4	0.4	0.5	0.5
7.0	0.5	0.3	0.4	0.5
7.5	0.2	0.2	0.4	0.4
8.0	0.2	0.3	0.2	0.4
8.5	-0.1	0.3	0.0	0.1
9.0	-0.1	-0.3	-0.1	-0.1
9.5	-0.1	-0.4	-0.3	-0.3
10.0	-0.3	-0.6	-0.3	-0.7
10.5	-0.3	-0.6	-0.4	-0.4
11.0	-0.4	-0.5	-0.4	-0.3
11.5	-0.6	-0.7	-0.5	-0.6
12.0	-0.6	-0.8	-0.4	-0.6

	Maximum Flood		Maximum Ebb	
	Time hr	Velocity fps	Time hr	Velocity fps
		Surface		
Base, 1974	4.5	0.7	0.0	-0.7
Plan C-1	5.5	0.7	12.0	-0.8
		Bottom		
Base, 1974	4.0	0.6	1.0	-0.5
Plan C-1	6.0	0.6	0.0	-0.8

* Time is expressed in hours after moon's transit of 74th meridian.

Table 31

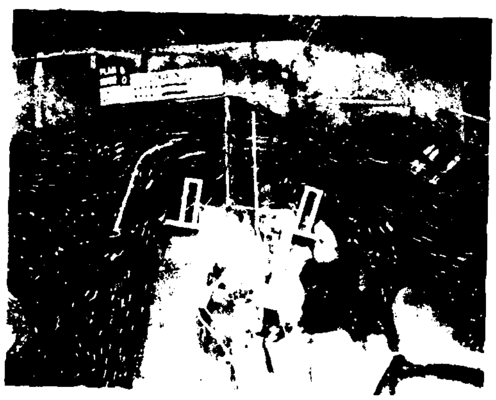
Effects of 40-Gate Barrier Plan C-1 on Dye Dispersion, 1-Cycle Release at Coney Island Plant Outfall, Average Dye Concentrations for Cycles 1 to 15

Location	High-Water Slack Measurement, ppb						Low-Water Slack Measurement, ppb					
	Surface			Bottom			Surface			Bottom		
	Without Barrier	With Barrier	Difference	Without Barrier	With Barrier	Difference	Without Barrier	With Barrier	Difference	Without Barrier	With Barrier	Difference
Approach Channel												
15 LB CH	0	0	0	0	0	0	0	0	0	0	0	0
1 NC	12	9	-3	11	9	-2	30	52	22	32	46	14
3 NC	65	16	-49	29	19	-10	60	106	46	60	94	34
1 V	[illegible]	15	16	15	15	0	40	70	30	44	66	22
2 V	11	6	-5	11	10	-1	37	67	30	42	67	25
3 V	37	36	-1	17	17	0	59	82	23	78	70	-8
Average			-7			-2			+25			+15
Coney Island Beach												
43 CI IS	25	6	-19	13	2	-11	41	59	18	39	8	-31
44 CI IS	4	10	6	2	0	-2	2	1	-1	1	0	-1
48 CO IS	12	6	-6	4	1	-3	1	0	-1	5	3	-2
Average			-6			-5			+5			-11
Basins												
14 SH BA	42	27	-15	0	0	0	40	32	-8	0	0	0
15 FB CH	41	34	-7	0	0	0	13	18	5	0	0	0
Average			-11			0			-1			0
Beach Channel												
26	43	36	-7	21	26	5	40	57	17	40	49	9
27	16	15	-1	14	18	4	31	52	21	34	51	17
0 BCH	12	20	8	39	23	-16	24	45	21	23	54	31
1 BCH	51	89	38	53	90	37	9	18	9	9	14	5
4 V	47	76	29	47	70	23	5	11	6	5	10	5
4 BCH	12	29	17	11	21	10	1	9	8	0	2	2
7 V	2	6	4	0	0	0	0	0	0	0	0	0
6 BCH	0	4	4	0	0	0	0	0	0	0	0	0
5 BCH	0	0	0	0	0	0	0	0	0	0	0	0
Average			+10			+7			+9			+8
Island Channel												
7 ICH	42	51	9	43	56	13	6	21	15	0	25	25
9 ICH	26	36	10	34	40	6	39	4	-35	4	1	-3
6 V	15	18	3	16	12	-4	2	2	0	2	0	-2
11 ICH	15	6	-9	10	1	-9	0	0	0	0	1	1
Average			+3			+2			-5			+5
Tidal Flats												
20 BFC	32	45	13	30	44	14	9	10	1	15	9	-6
22	22	25	3	0	10	10	24	29	5	2	5	3
5 V	20	0	-20	22	27	5	4	16	12	3	1	-2
21 PB PC	0	2	2	0	0	0	0	0	0	0	0	0
9 V	1	2	1	0	0	0	0	0	0	0	0	0
8 V	0	1	1	0	0	0	0	0	0	0	0	0
Average			0			+5			+3			-1
Basins												
16 PA BA	0	10	10	7	0	-7	0	1	1	4	0	-4
17	4	3	-1	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0
19 BE BS	0	0	0	0	0	0	0	0	0	0	0	0
Average			+2			-2			0			-1

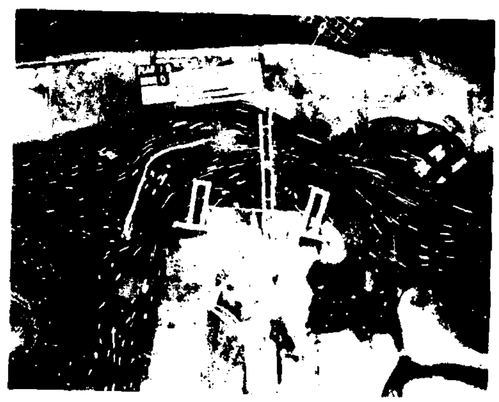
[illegible] Bergen Beach, [illegible]

						Low-Water Slack Measurements, ppt					
						Surface			Bottom		
	[illegible]	[illegible]	Without Barrier	With Barrier	Difference	Without Barrier	With Barrier	Difference	Without Barrier	With Barrier	Difference
Average			[illegible]								
Phoenix											
Average			[illegible]								

BASE



PLAN 8-A



PLAN 15-A

NEW YORK HARBOR MODEL

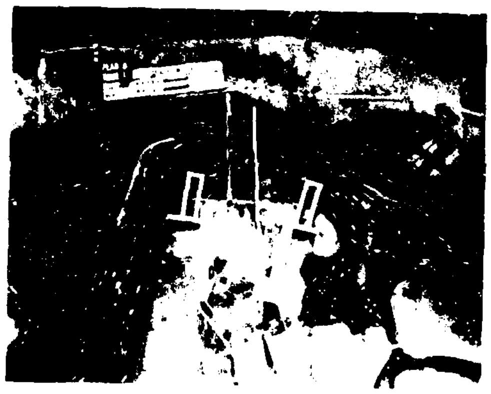
JAMAICA BAY HURRICANE
SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN 8-A, AND PLAN 15-A

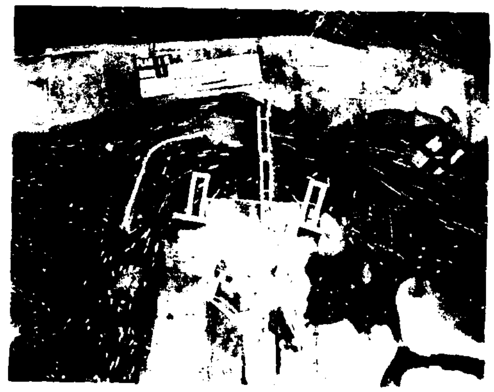
HOUR 0

PHOTO 1

BASE



PLAN 8-A



PLAN 15-A

NEW YORK HARBOR MODEL

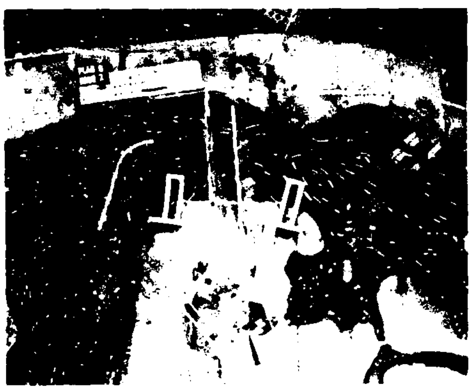
JAMAICA BAY HURRICANE
SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN 8-A, AND PLAN 15-A

HOUR 1

PHOTO 2

BASE



PLAN 8-A

PLAN 15-A

NEW YORK HARBOR MODEL

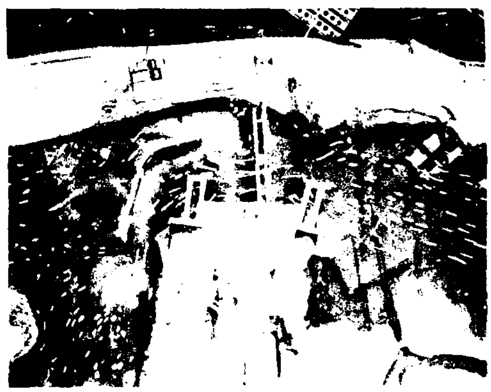
JAMAICA BAY HURRICANE
SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN 8-A, AND PLAN 15-A

HOUR 2

BASE

PLAN 8-A



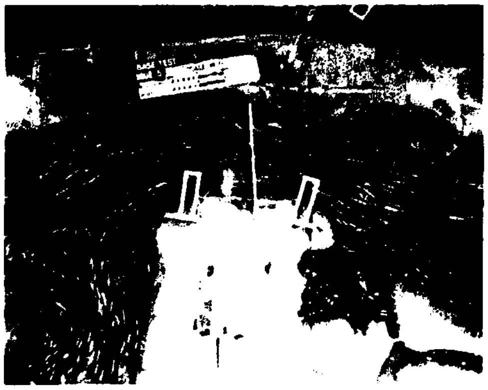
PLAN 15-A

NEW YORK HARBOR MODEL

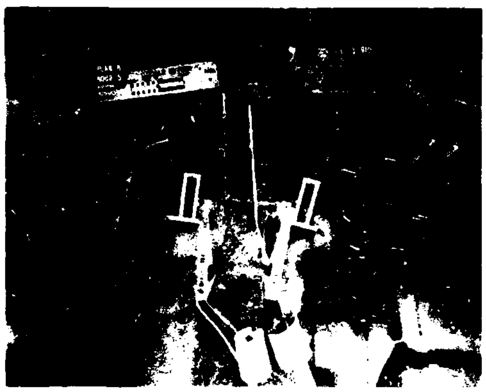
JAMAICA BAY HURRICANE
SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERN
BASE, PLAN 8-A, AND PLAN

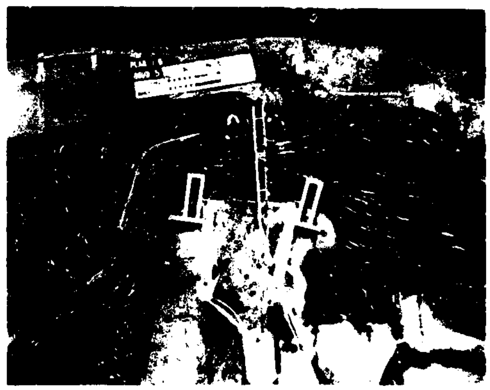
PHOTO 4



BASE



PLAN 8-A



PLAN 15-A

NEW YORK HARBOR MODEL

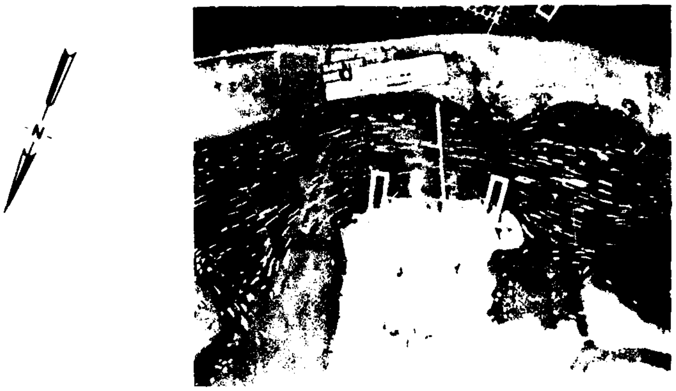
JAMAICA BAY HURRICANE SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN 8-A, AND PLAN 15-A

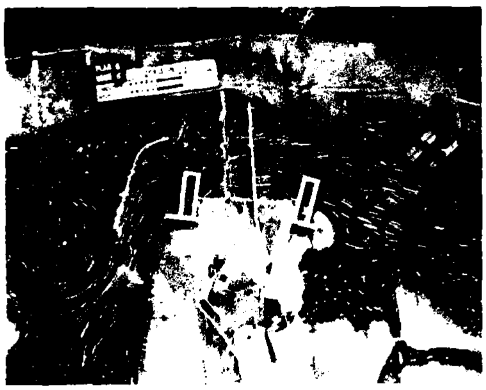
HOUR 5

PROTOTYPE SCALE
5 0 5 10 15 FPS

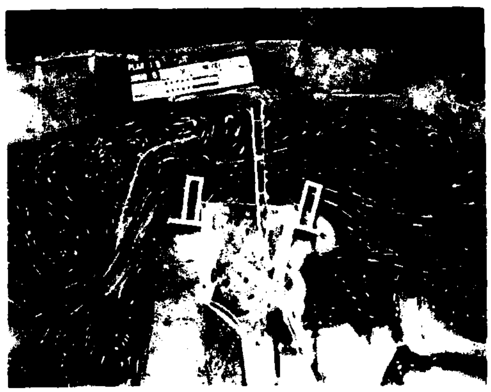
PHOTO 6



BASE



PLAN 8-A



PLAN 15-A

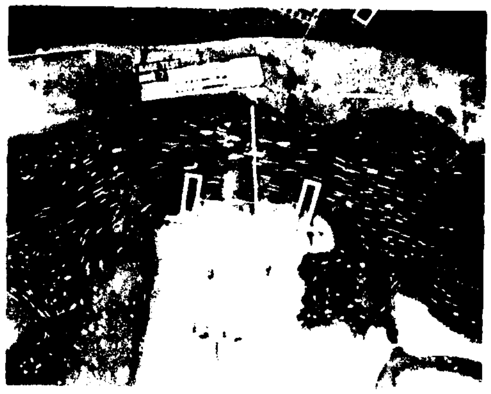
NEW YORK HARBOR MODEL

JAMAICA BAY HURRICANE SURGE BARRIER STUDY

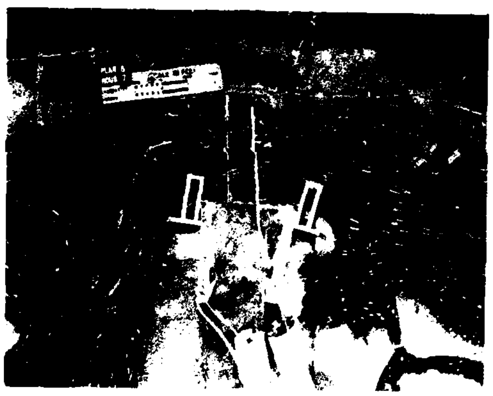
EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN 8-A, AND PLAN 15-A

HOUR 6

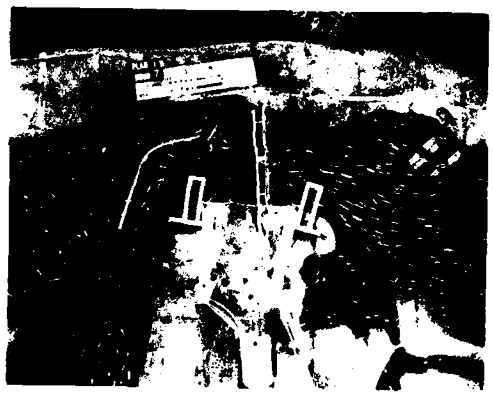
PHOTO 7



BASE



PLAN 8-A



PLAN 15-A

NEW YORK HARBOR MODEL

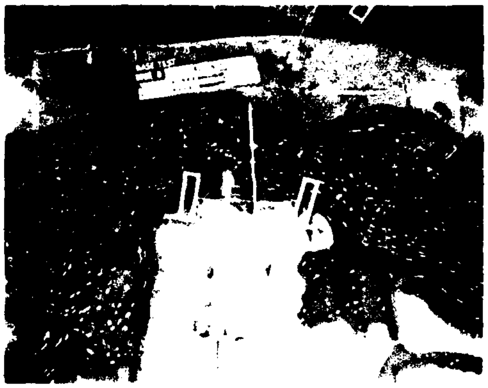
JAMAICA BAY HURRICANE SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN 8-A, AND PLAN 15-A

HOUR 7

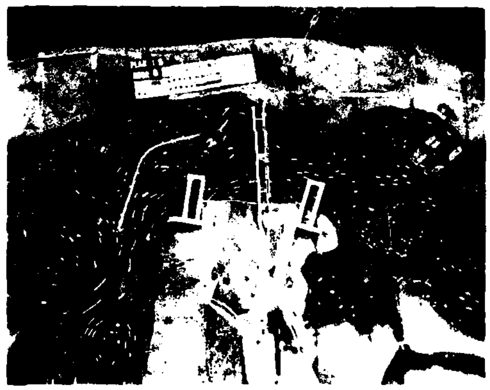
PROTOTYPE SCALE
5 0 5 10 15 FPS

PHOTO 8



BASE

PLAN 8-A



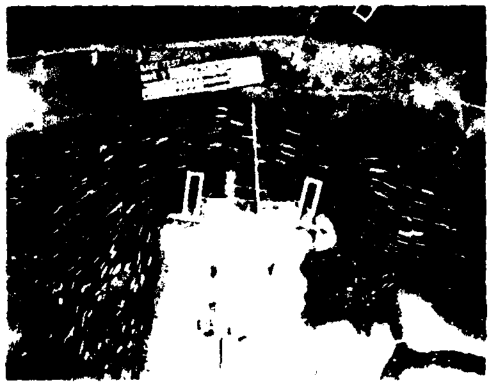
PLAN 15-A

NEW YORK HARBOR MODEL

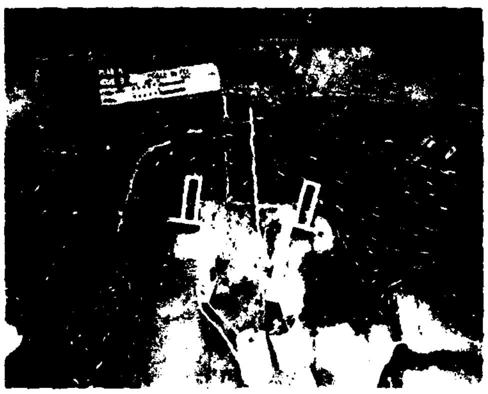
JAMAICA BAY HURRICANE SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN 8-A, AND PLAN 15-A

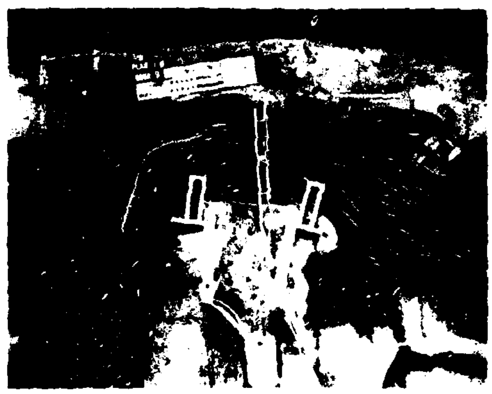
HOUR 8



BASE



PLAN 8-A



PLAN 15-A

NEW YORK HARBOR MODEL

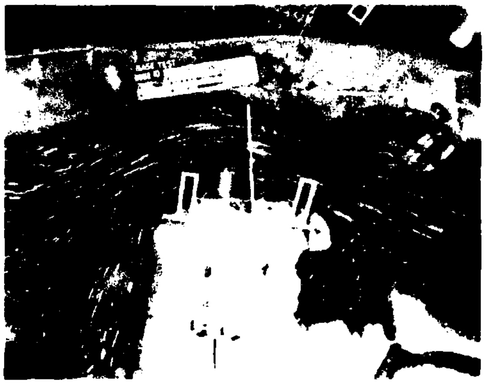
JAMAICA BAY HURRICANE
SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN 8-A, AND PLAN 15-A

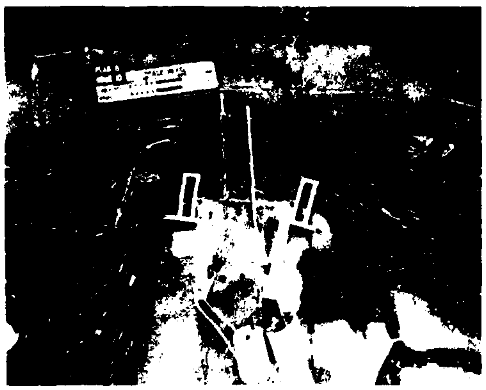
HOUR 9

PROTOTYPE SCALE

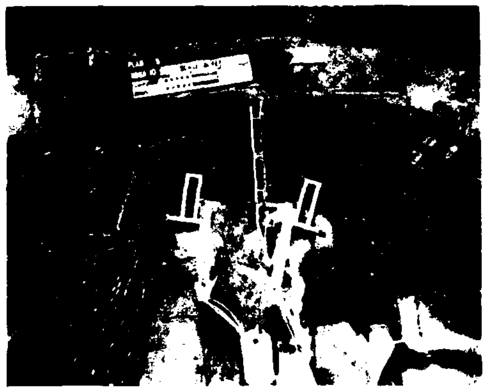
PHOTO 10



BASE



PLAN 8-A



PLAN 15-A

NEW YORK HARBOR MODEL

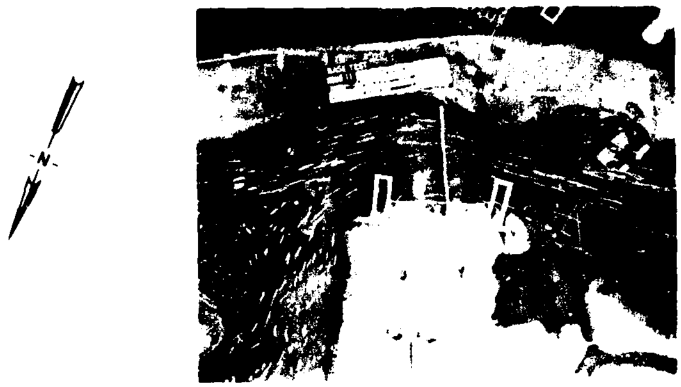
JAMAICA BAY HURRICANE SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN 8-A, AND PLAN 15-A

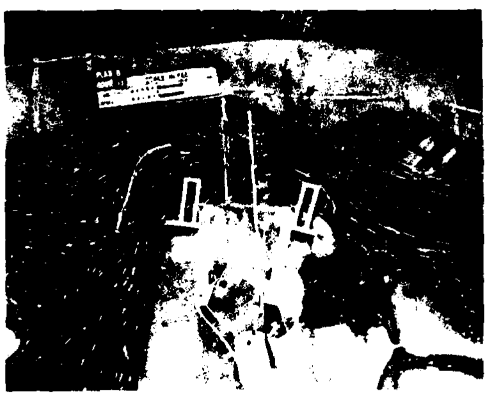
HOUR 10

PROTOTYPE SCALE
5 0 5 10 15 FPS

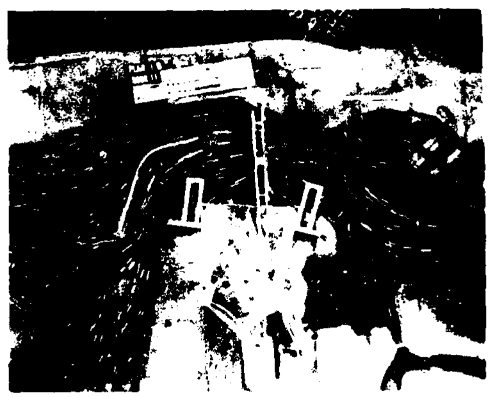
PHOTO 11



BASE



PLAN 8-A



PLAN 15-A

NEW YORK HARBOR MODEL

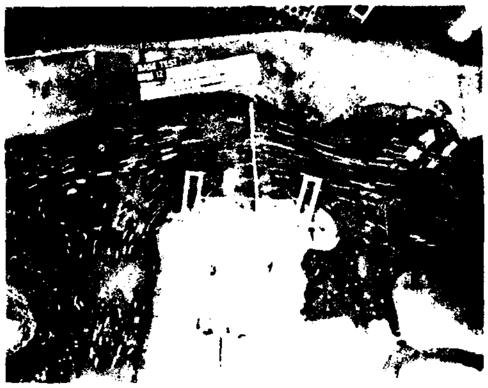
JAMAICA BAY HURRICANE SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN 8-A, AND PLAN 15-A

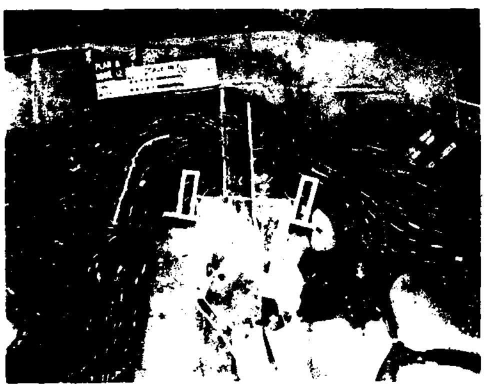
HOUR 11

PROTOTYPE SCALE
5 0 5 10 15 FPS

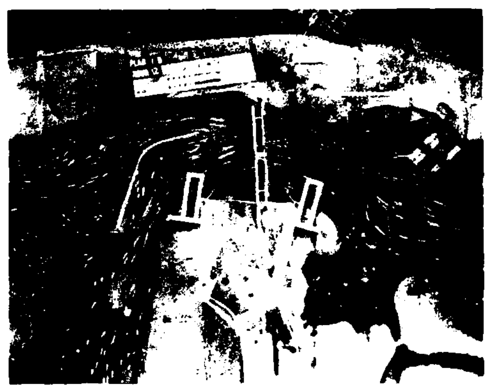
PHOTO 12



BASE



PLAN 8-A



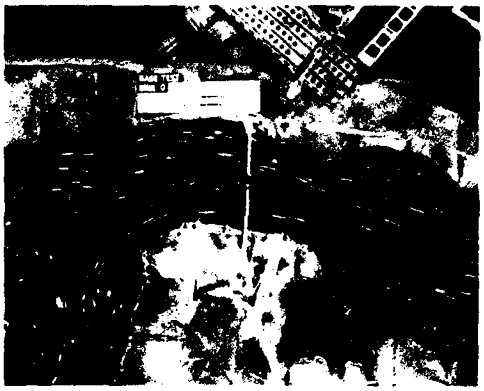
PLAN 15-A

NEW YORK HARBOR MODEL

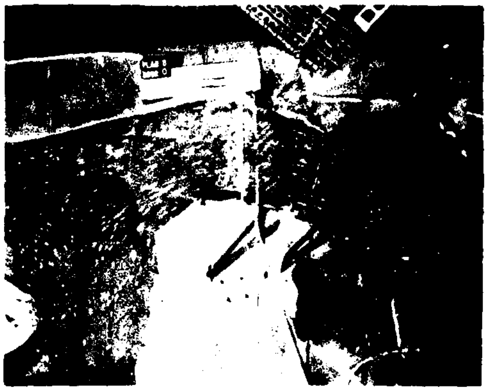
JAMAICA BAY HURRICANE SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN 8-A, AND PLAN 15-A

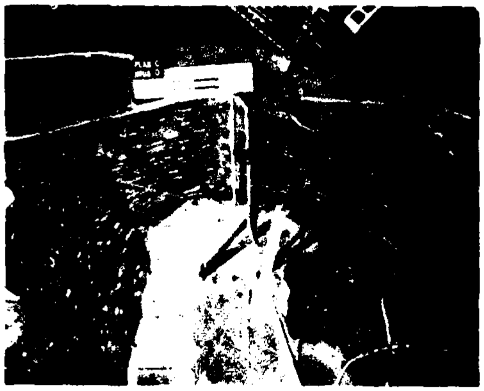
HOUR 12



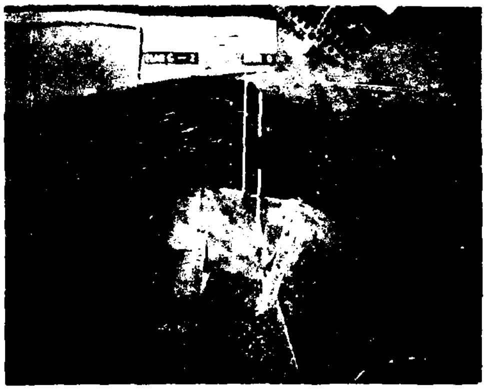
BASE



PLAN B



PLAN C-1



PLAN C-2

PLAN C-3

NEW YORK HARBOR MODEL

JAMAICA BAY HURRICANE SURGE BARRIER STUDY

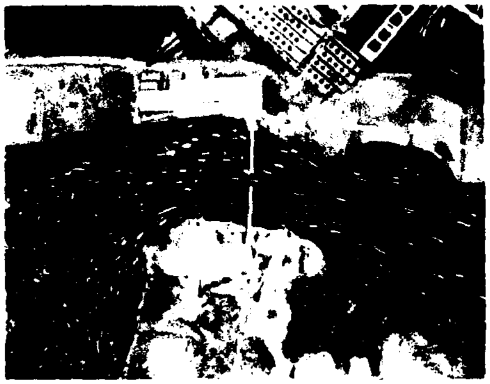
EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN B, PLAN C-1, PLAN C-2,
AND PLAN C-3

HOUR 0

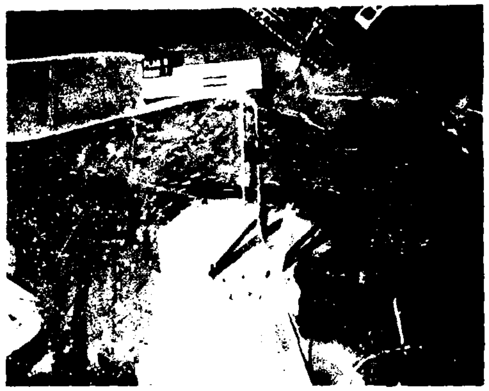
PROTOTYPE SCALE

5 5 FPS

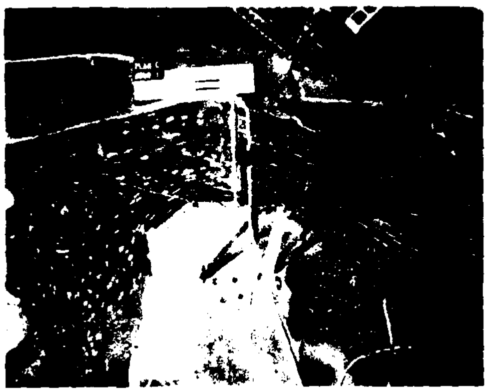
PHOTO 14



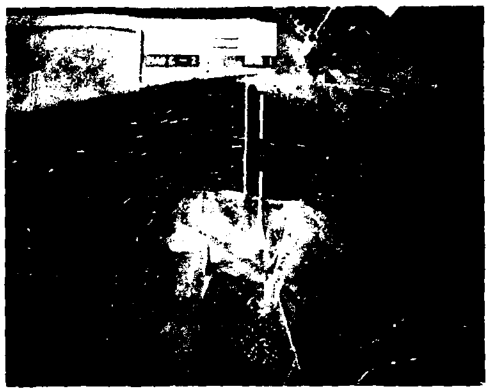
BASE



PLAN B



PLAN C-1



PLAN C-2

PLAN C-3

NEW YORK HARBOR MODEL

JAMAICA BAY HURRICANE
SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN B, PLAN C-1, PLAN C-2,
AND PLAN C-3

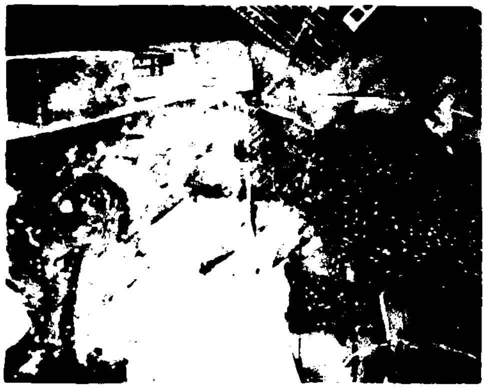
HOUR 1

PROTOTYPE SCALE

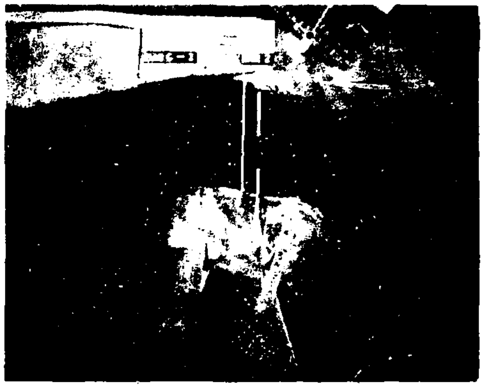
FPS

BASE

PLAN B



PLAN C-1



PLAN C-2

PLAN C-3

NEW YORK HARBOR MODEL

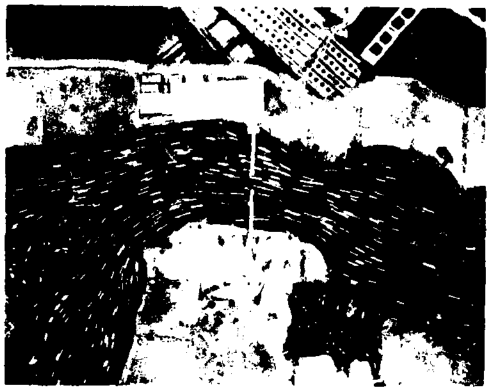
JAMAICA BAY HURRICANE SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN B, PLAN C-1, PLAN C-2,
AND PLAN C-3

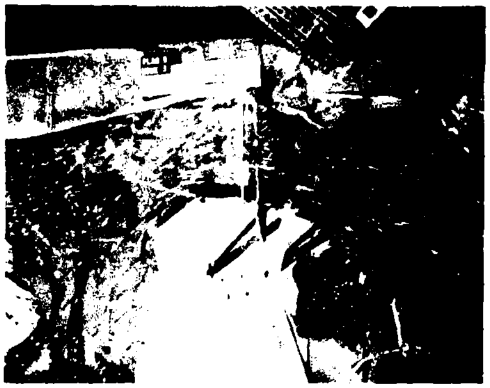
HOUR 2

PROTOTYPE SCALE

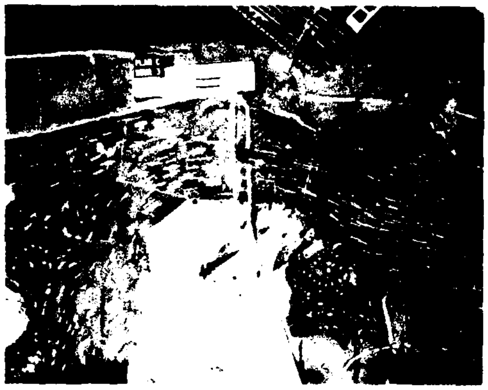
PHOTO 16



BASE

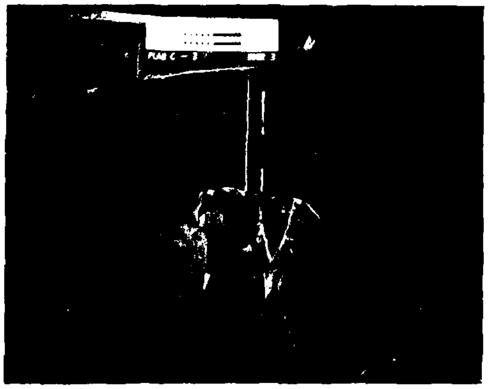


PLAN B



PLAN C-1

PLAN C-2



PLAN C-3

NEW YORK HARBOR MODEL

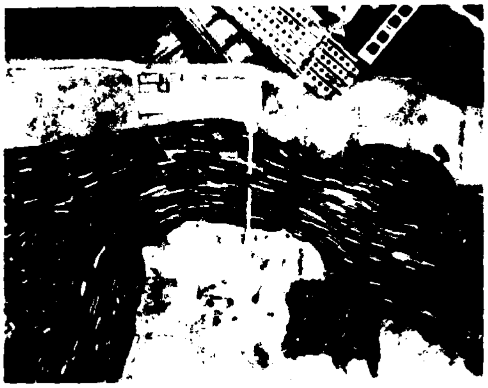
JAMAICA BAY HURRICANE SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN B, PLAN C-1, PLAN C-2,
AND PLAN C-3

HOUR 3

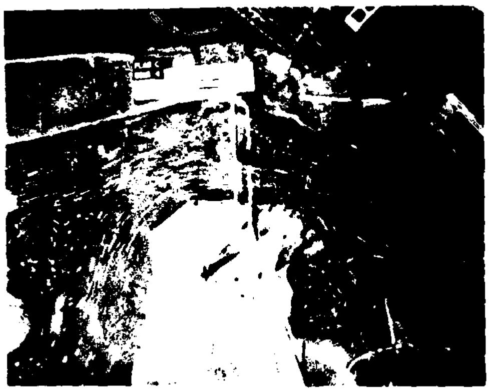
[illegible] OTYPE [illegible]
FPS

PHOTO 17

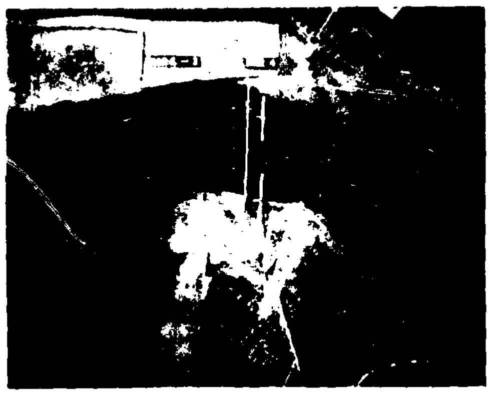


BASE

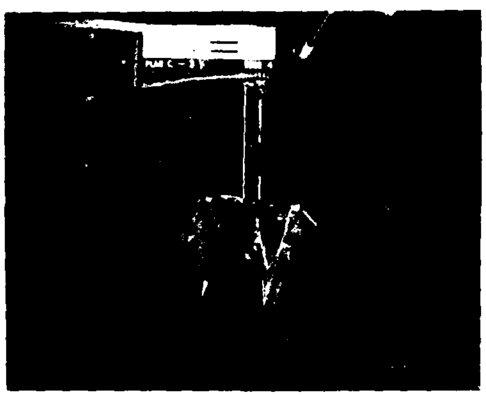
PLAN B



PLAN C-1



PLAN C-2



PLAN C-3

NEW YORK HARBOR MODEL

JAMAICA BAY HURRICANE SURGE BARRIER STUDY

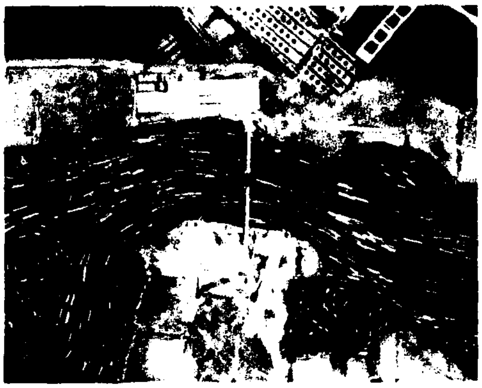
EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN B, PLAN C-1, PLAN C-2,
AND PLAN C-3

HOUR 4

PROTOTYPE SCALE

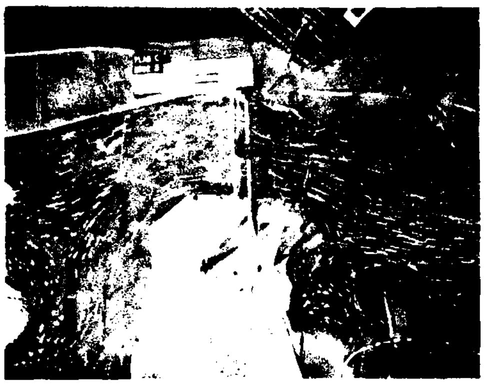
FPS

PHOTO 18

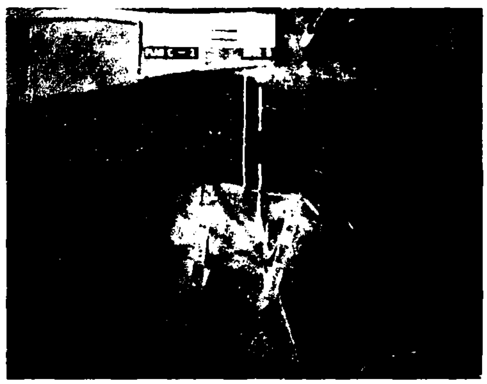


BASE

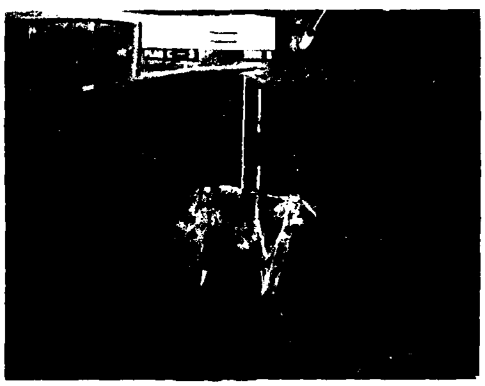
PLAN B



PLAN C-1



PLAN C-2



PLAN C-3

NEW YORK HARBOR MODEL

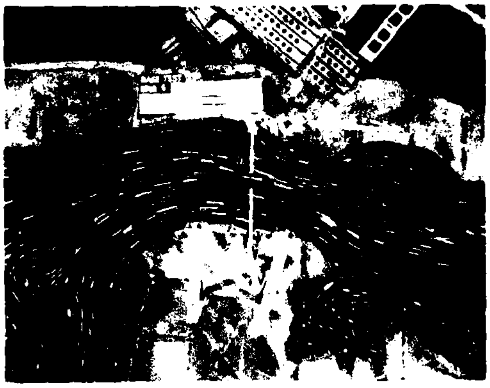
JAMAICA BAY HURRICANE SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN B, PLAN C-1, PLAN C-2,
AND PLAN C-3

HOUR 5

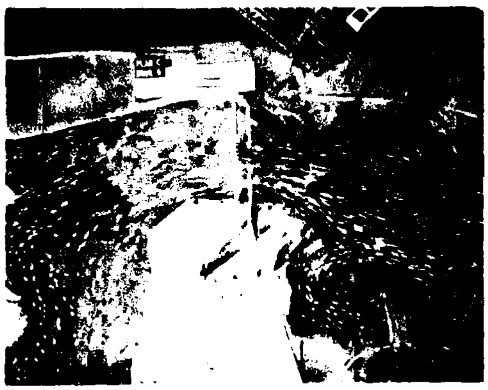
PROTOTYPE SCALE

PHOTO 19

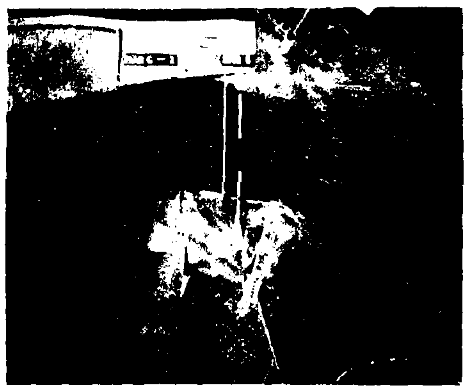


BASE

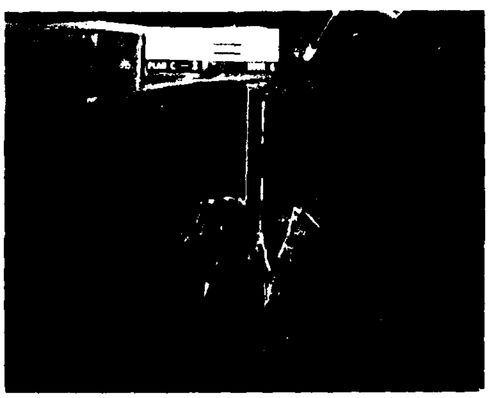
PLAN B



PLAN C-1



PLAN C-2



PLAN C-3

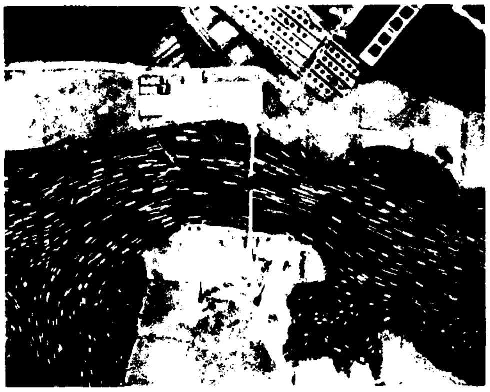
NEW YORK HARBOR MODEL

JAMAICA BAY HURRICANE
SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN B, PLAN C-1, PLAN C-2,
AND PLAN C-3

HOUR 6

PROTOTYPE SCALE

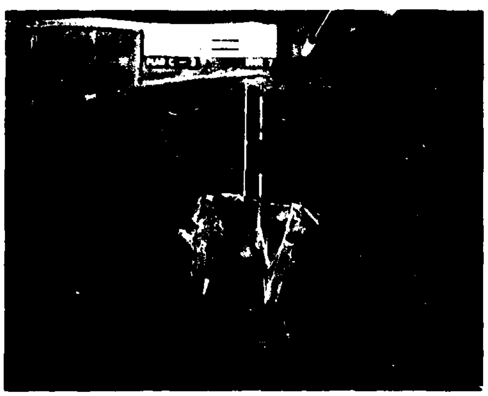


BASE

PLAN B

PLAN C-1

PLAN C-2



PLAN C-3

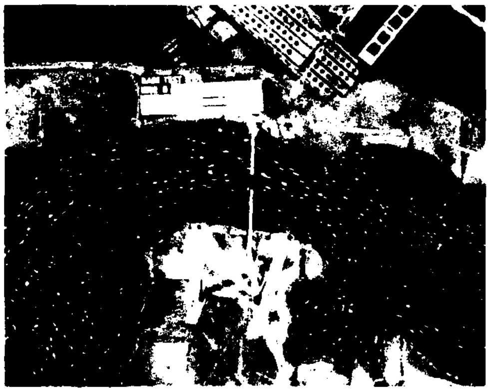
NEW YORK HARBOR MODEL

JAMAICA BAY HURRICANE SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN B, PLAN C-1, PLAN C-2,
AND PLAN C-3

HOUR 7

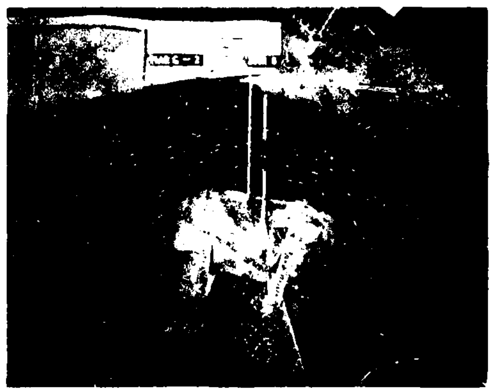
PROTOTYPE SCALE



BASE

PLAN B

PLAN C-1



PLAN C-2

PLAN C-3

NEW YORK HARBOR MODEL

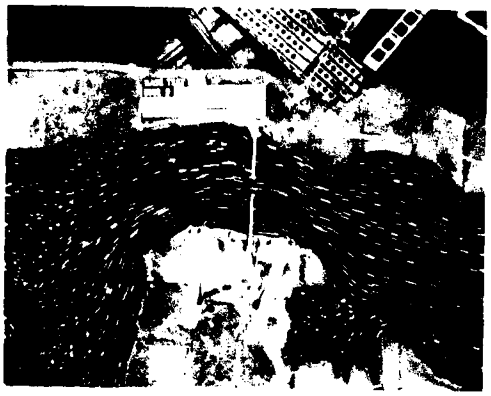
JAMAICA BAY HURRICANE SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN B, PLAN C-1, PLAN C-2,
AND PLAN C-3

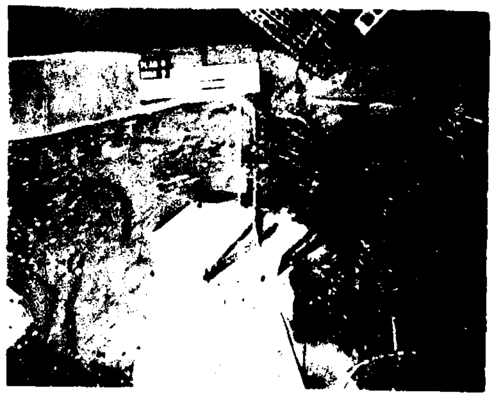
HOUR 8

PROTOTYPE SCALE

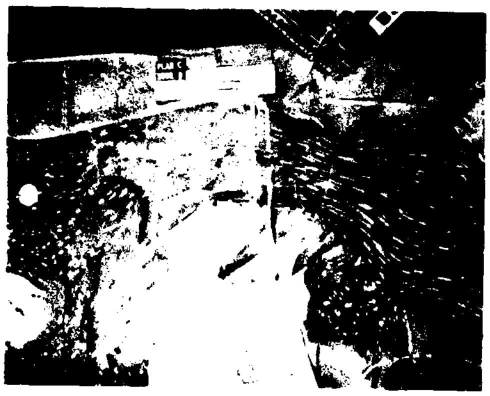
PHOTO 22



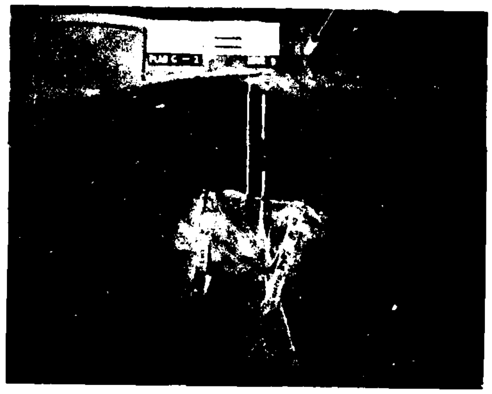
BASE



PLAN B



PLAN C-1



PLAN C-2

PLAN C-3

NEW YORK HARBOR MODEL

JAMAICA BAY HURRICANE SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN B, PLAN C-1, PLAN C-2,
AND PLAN C-3

HOUR 9

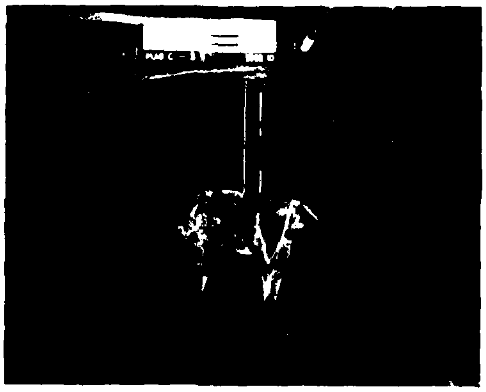
[illegible]

BASE

PLAN B

PLAN C-1

PLAN C-2



PLAN C-3

NEW YORK HARBOR MODEL

JAMAICA BAY HURRICANE SURGE BARRIER STUDY

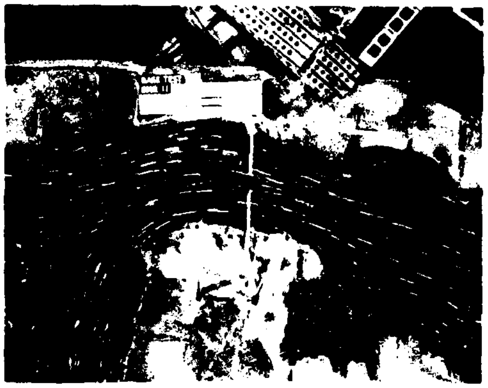
EFFECTS OF SURFACE CURRENT PATTERNS ON BASE, PLAN B, PLAN C-1, PLAN C-2, AND PLAN C-3

HOUR 10

PROTOTYPE SCALE

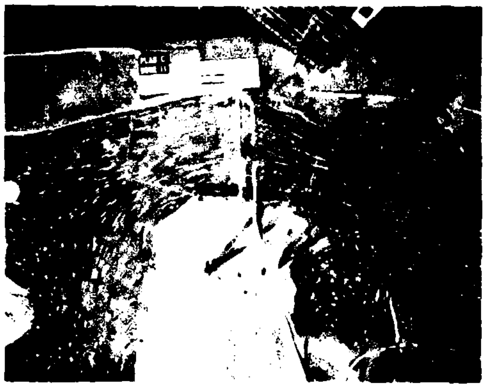
FPS

PHOTO 24



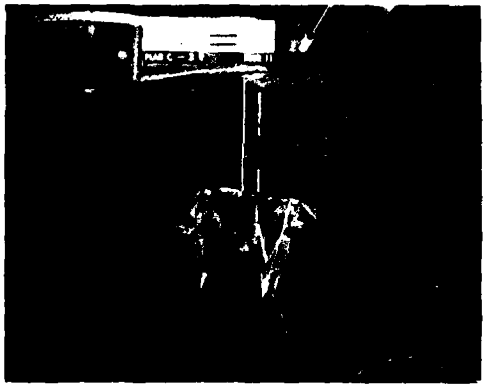
BASE

PLAN B



PLAN C-1

PLAN C-2



PLAN C-3

NEW YORK HARBOR MODEL

JAMAICA BAY HURRICANE SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN B, PLAN C-1, PLAN C-2,
AND PLAN C-3

HOUR 11

PROTOTYPE SCALE

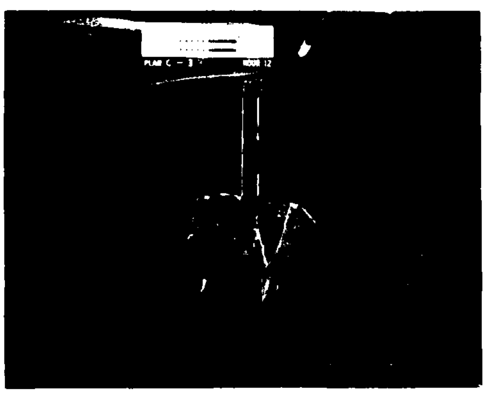
FPS

BASE

PLAN B

PLAN C-1

PLAN C-2



PLAN C-3

NEW YORK HARBOR MODEL

JAMAICA BAY HURRICANE
SURGE BARRIER STUDY

EFFECTS OF
SURFACE CURRENT PATTERNS ON
BASE, PLAN B, PLAN C-1, PLAN C-2,
AND PLAN C-3

HOUR 12

PROTOTYPE SCALE
FPS

PHOTO 26

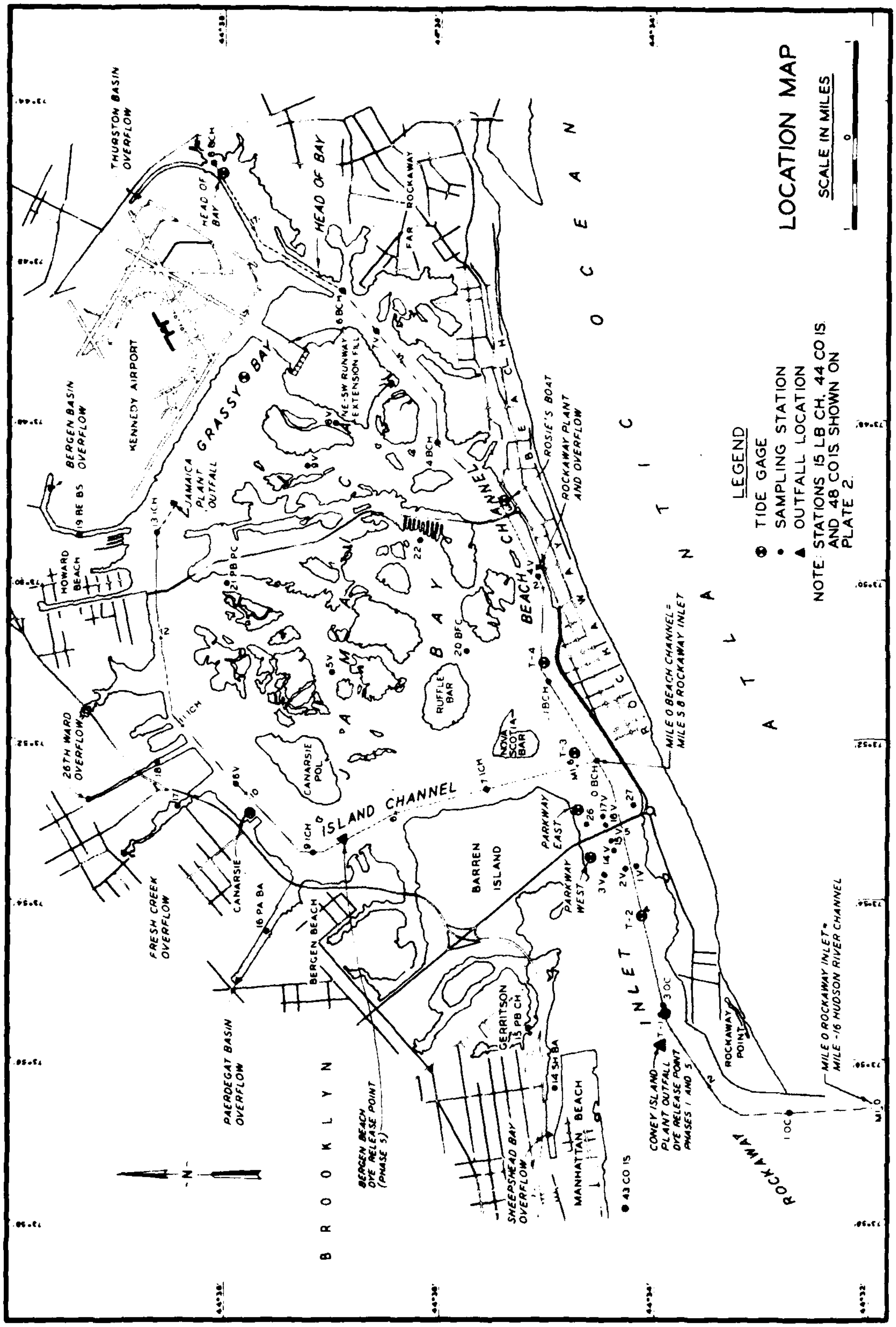
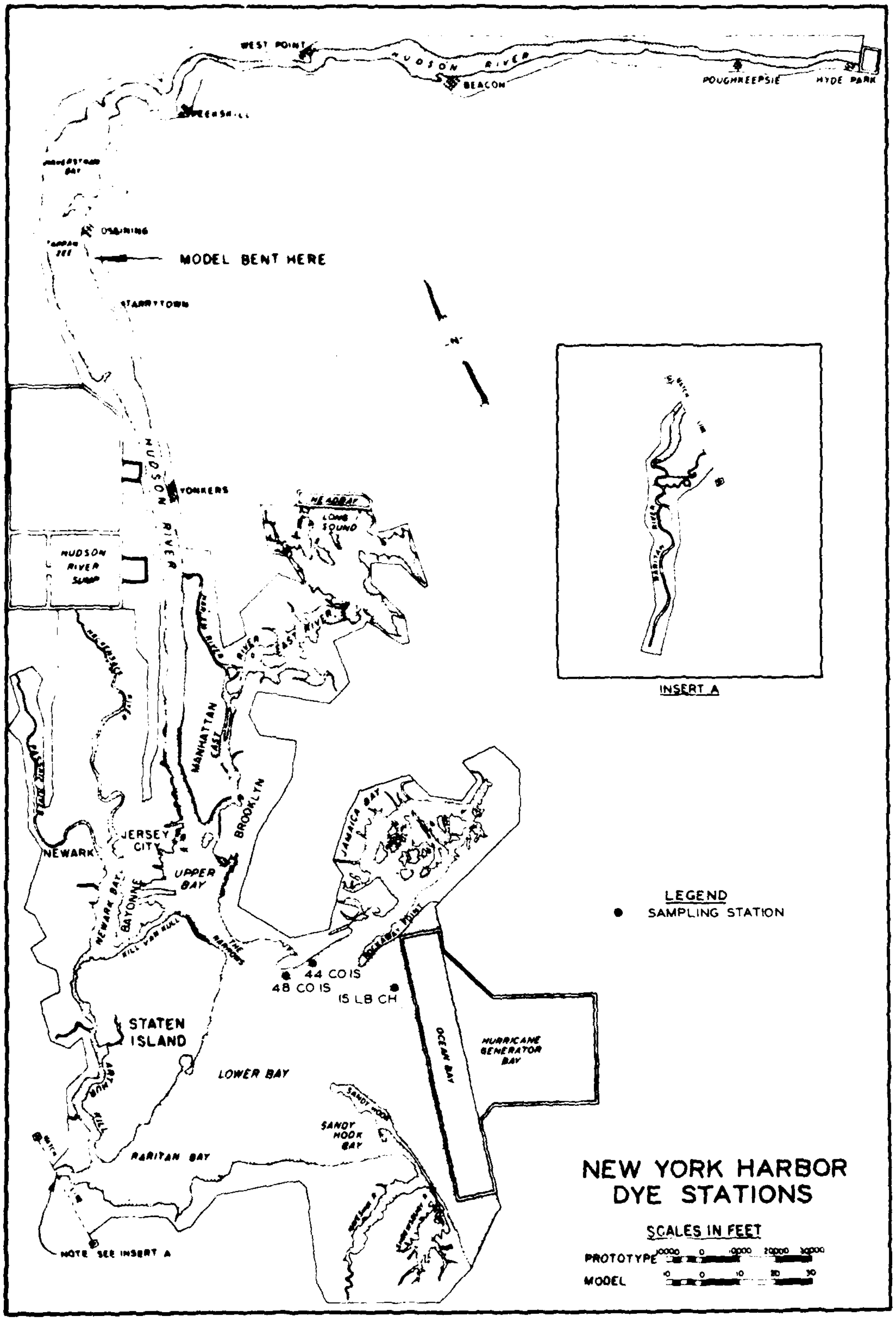
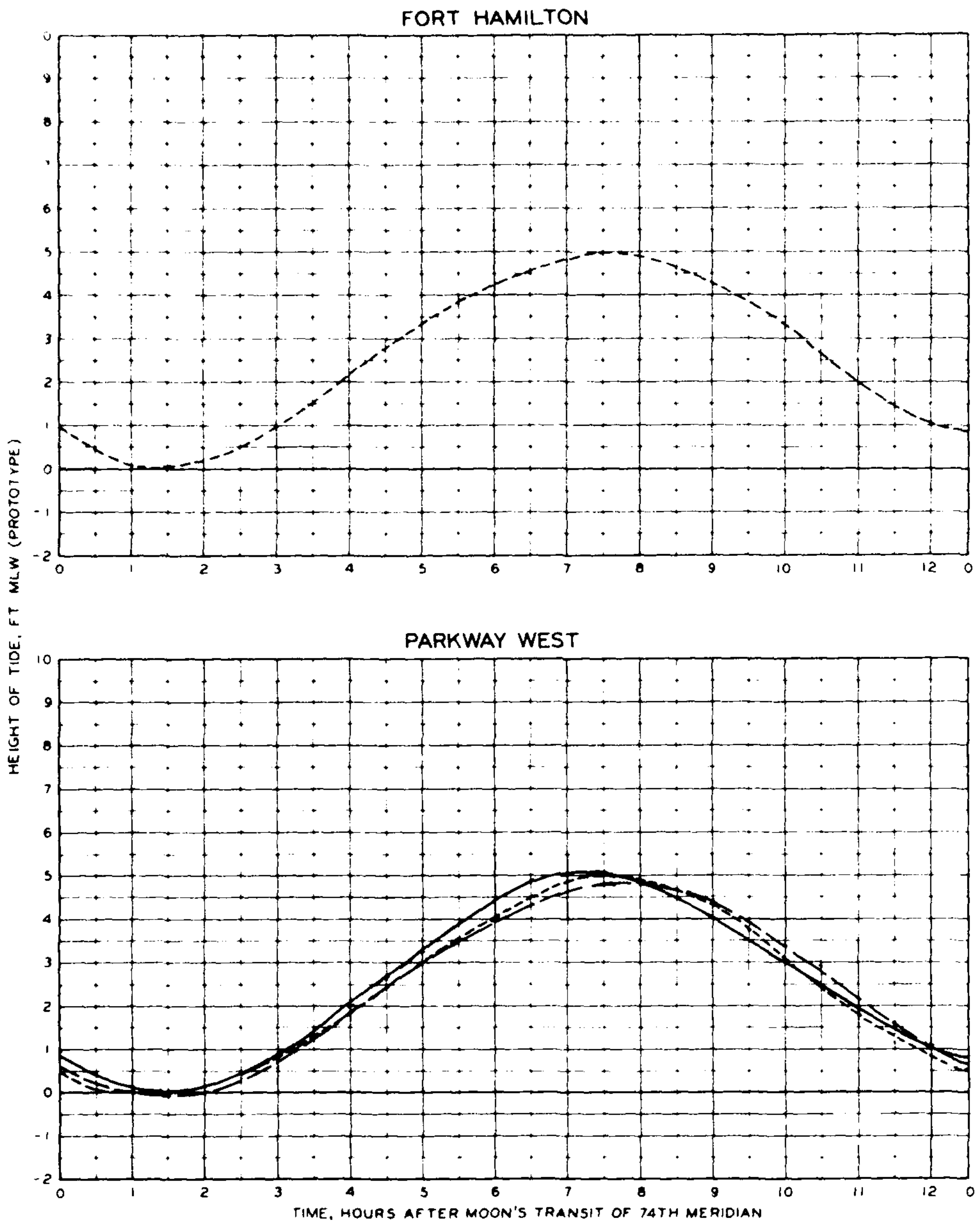

LOCATION MAP
SCALE IN MILES
0
LEGEND
TIDE GAGE
SAMPLING STATION
OUTFALL LOCATION
NOTE: STATIONS 15 LB CH, 44 CO IS AND 48 CO IS SHOWN ON PLATE 2.
ATLANTIC OCEAN
BROOKLYN
ROCKAWAY
ROCKAWAY INLET
JAMAICA BAY
GRASSY BAY
ISLAND CHANNEL
BEACH CHANNEL
HEAD OF BAY
KENNEDY AIRPORT
NE-SW RUNWAY EXTENSION FILL
THURSTON BASIN OVERFLOW
BERGEN BASIN OVERFLOW
JAMAICA PLANT OUTFALL
HOWARD BEACH
26TH WARD OVERFLOW
FRESH CREEK OVERFLOW
CANARSIE
CANARSIE POL
PAERDEGAT BASIN OVERFLOW
BERGEN BEACH
BERGEN BEACH DYE RELEASE POINT (PHASE 5)
BARREN ISLAND
RUFFLE BAR
NOVA SCOTIA BAR
PARKWAY EAST
PARKWAY WEST
GERRITSON
SHEEPSHEAD BAY OVERFLOW
MANHATTAN BEACH
CONEY ISLAND PLANT OUTFALL DYE RELEASE POINT PHASES 1 AND 3
ROCKAWAY POINT
FAR ROCKAWAY
ROSIE'S BOAT
ROCKAWAY PLANT AND OVERFLOW
MILE 0 BEACH CHANNEL = MILE 5.8 ROCKAWAY INLET
MILE 0 ROCKAWAY INLET = MILE -16 HUDSON RIVER CHANNEL

PLATE 1



WEST POINT
HUDSON RIVER
BEACON
POUGHKEEPSIE
HYDE PARK
OSSINING
MODEL BENT HERE
TARRYTOWN
YONKERS
HUDSON RIVER SUMP
LONG SOUND
EAST RIVER
MANHATTAN
BROOKLYN
JERSEY CITY
NEWARK
UPPER BAY
BAYONNE
NEWARK BAY
JAMAICA BAY
44 CO IS
48 CO IS
15 LB CH
STATEN ISLAND
LOWER BAY
OCEAN BAY
HURRICANE GENERATOR BAY
SANDY HOOK BAY
RARITAN BAY
NOTE SEE INSERT A
INSERT A
LEGEND
SAMPLING STATION
NEW YORK HARBOR
DYE STATIONS
SCALES IN FEET
PROTOTYPE
MODEL

PLATE 2



LEGEND

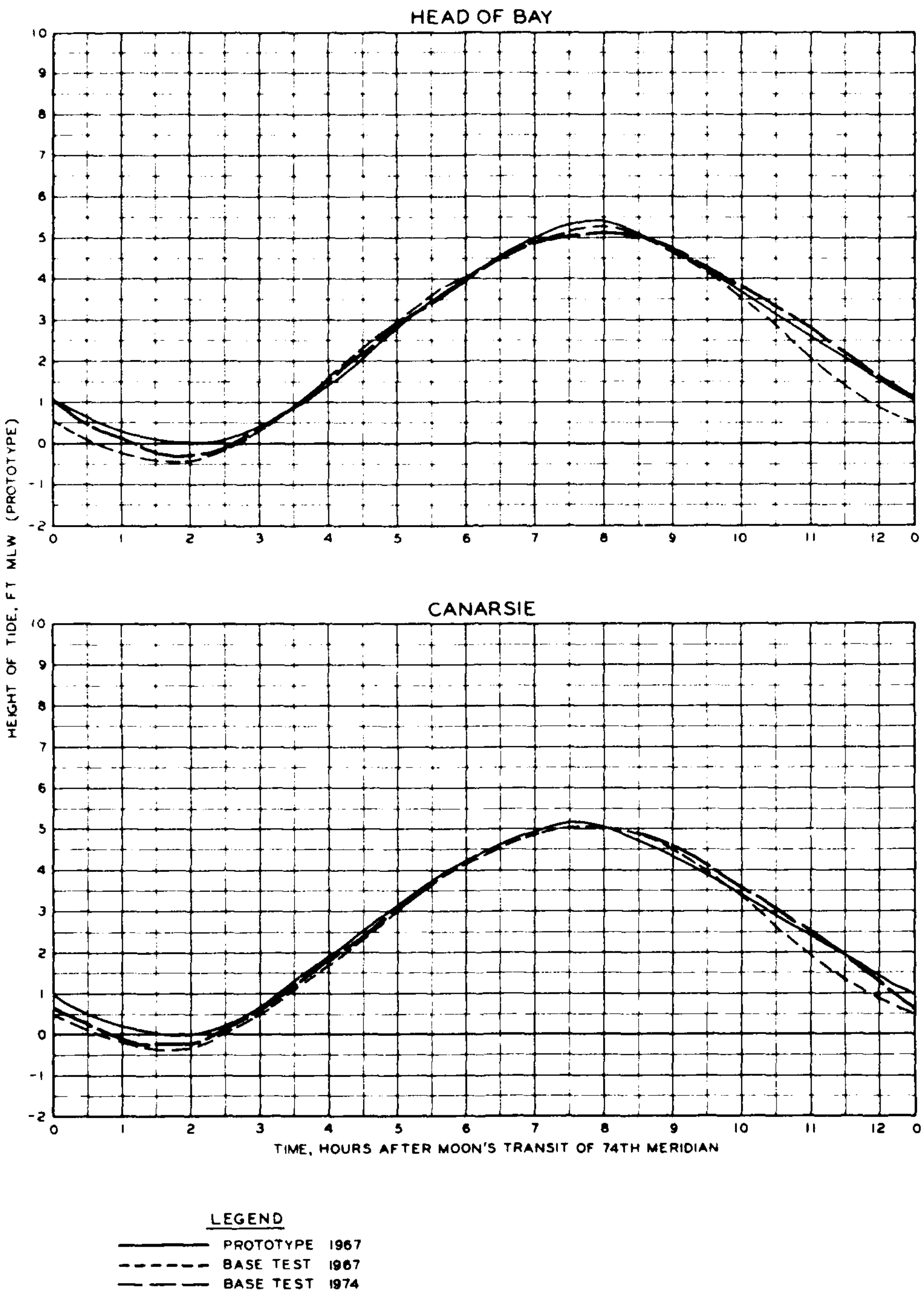
———	PROTOTYPE (1967)
- - - - - -	BASE TEST (1967)
— — —	BASE TEST (1974)

MODEL TEST DATA

TIDE	MEAN
SUMP SALINITY	30,000-PPM TOTAL SALT
FRESHWATER DISCHARGE	2,000 CFS (MEAN) HUDSON AT HYDE PARK

VERIFICATION OF TIDAL HEIGHTS

STATIONS FORT HAMILTON AND PARKWAY WEST

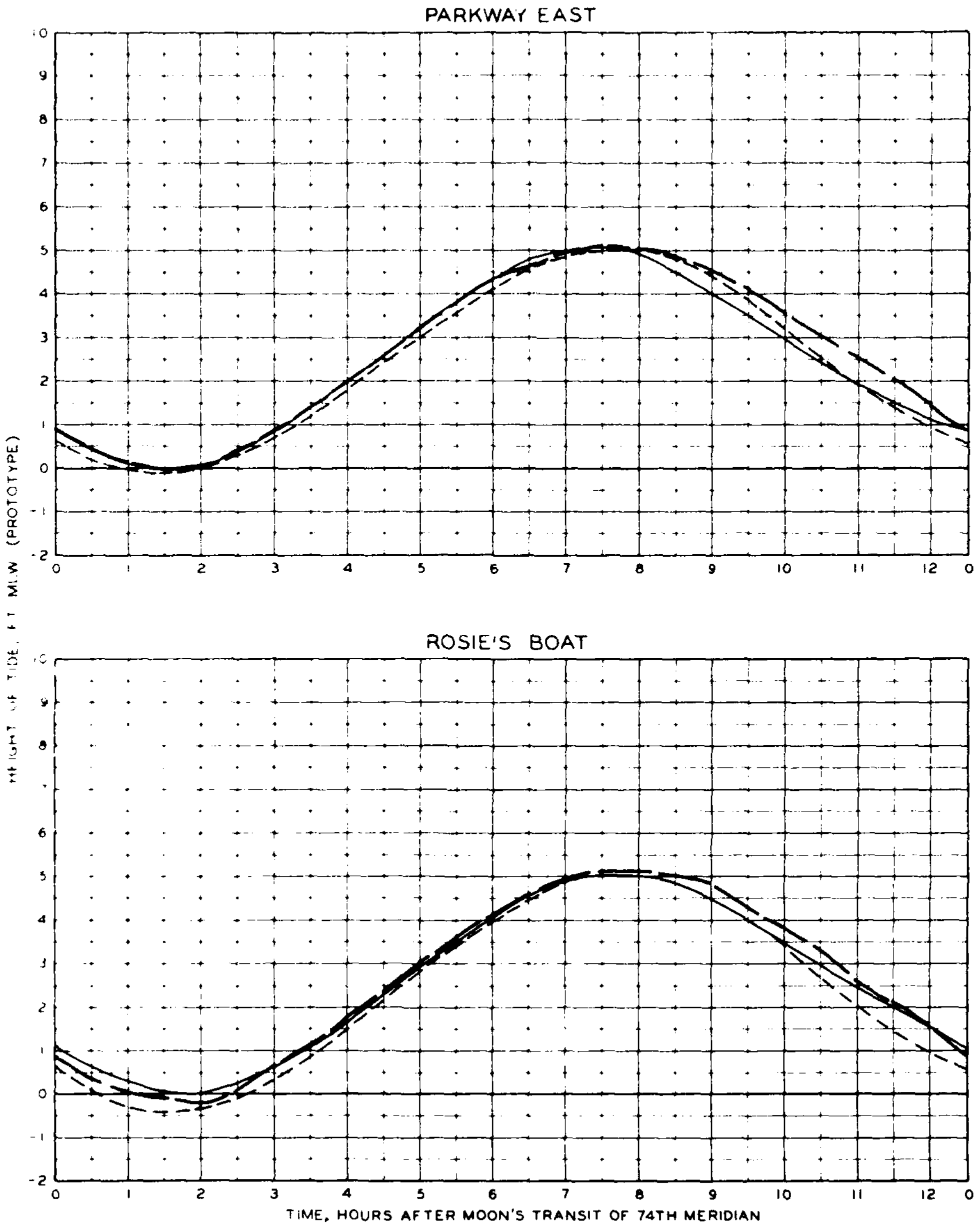


MODEL TEST DATA

TIDE	MEAN
SUMP SALINITY	30,000-PPM TOTAL SALT
FRESHWATER DISCHARGE	12,000 CFS (MEAN) HUDSON AT HYDE PARK

VERIFICATION OF TIDAL HEIGHTS

STATIONS HEAD OF BAY AND CANARSIE



LEGEND

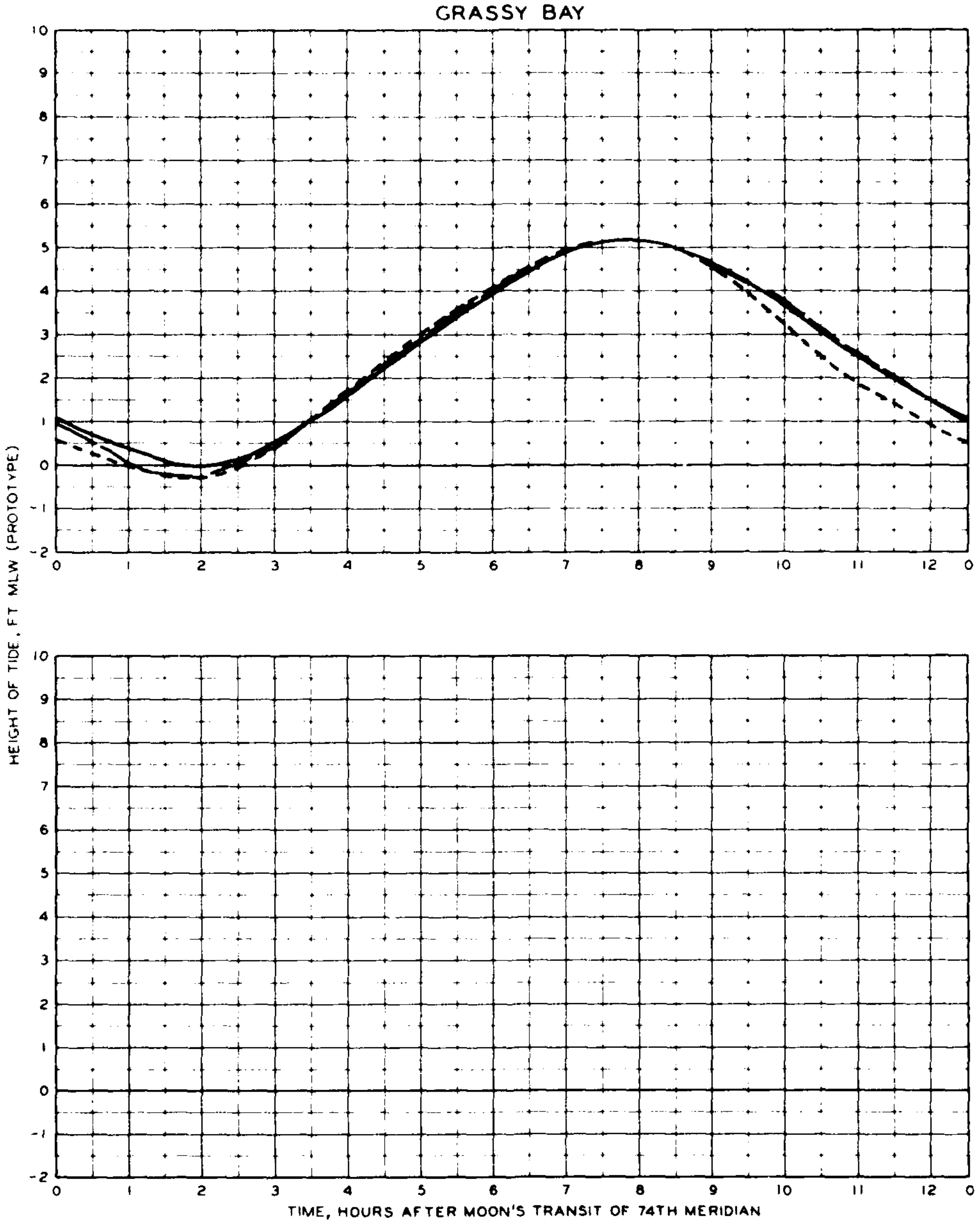
PROTOTYPE 1967
BASE TEST 1967
BASE TEST 1974

MODEL TEST DATA

TIDE	MEAN
SUMP SALINITY	30,000-PPM TOTAL SALT
FRESHWATER DISCHARGE	12,000 CFS (MEAN)

VERIFICATION OF TIDAL HEIGHTS

STATIONS PARKWAY EAST AND ROSIE'S BOAT



LEGEND

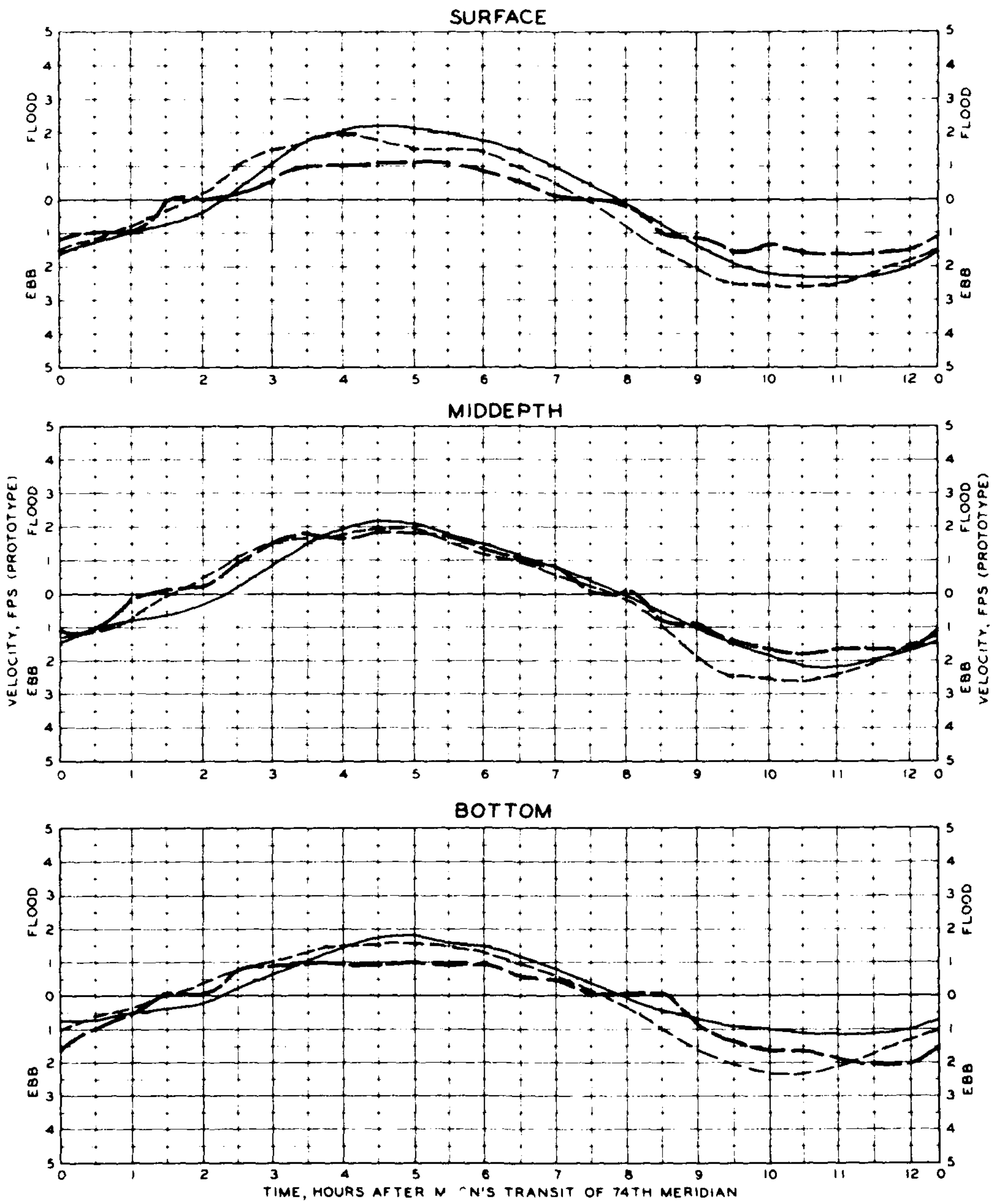
———	PROTOTYPE 1967
- - - -	BASE TEST 1967
— — —	BASE TEST 1974

MODEL TEST DATA

TIDE	MEAN
SUMP SALINITY	30,000 PPM TOTAL SALT
FRESHWATER DISCHARGE	12,000 CFS (MEAN) HUDSON AT HYDE PARK

VERIFICATION OF TIDAL HEIGHTS

STATION GRASSY BAY



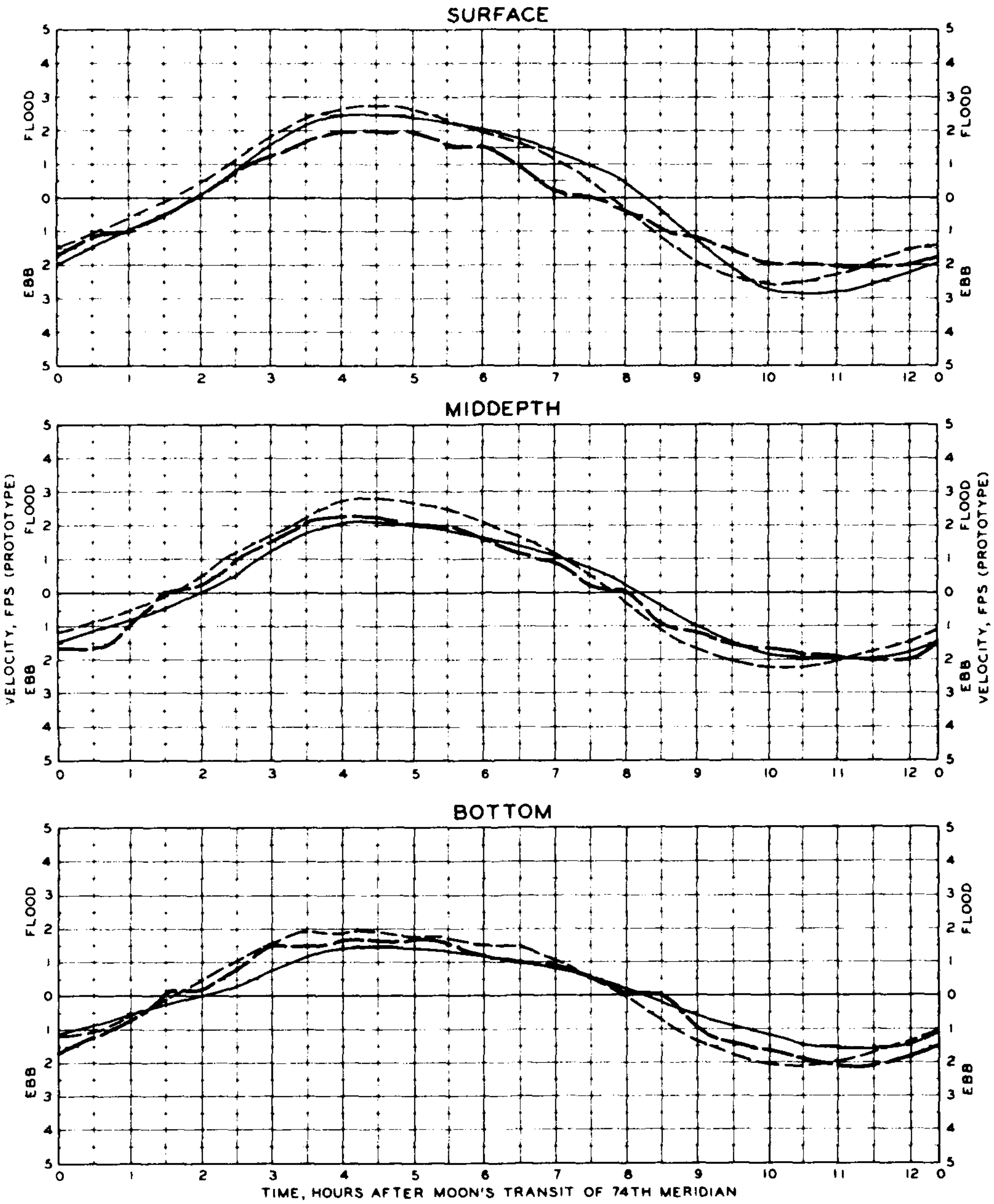
MODEL TEST DATA

TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— PROTOTYPE 1967
- - - - - BASE TEST 1967
— — — BASE TEST 1974

VERIFICATION OF
CURRENT VELOCITIES
STATION IV



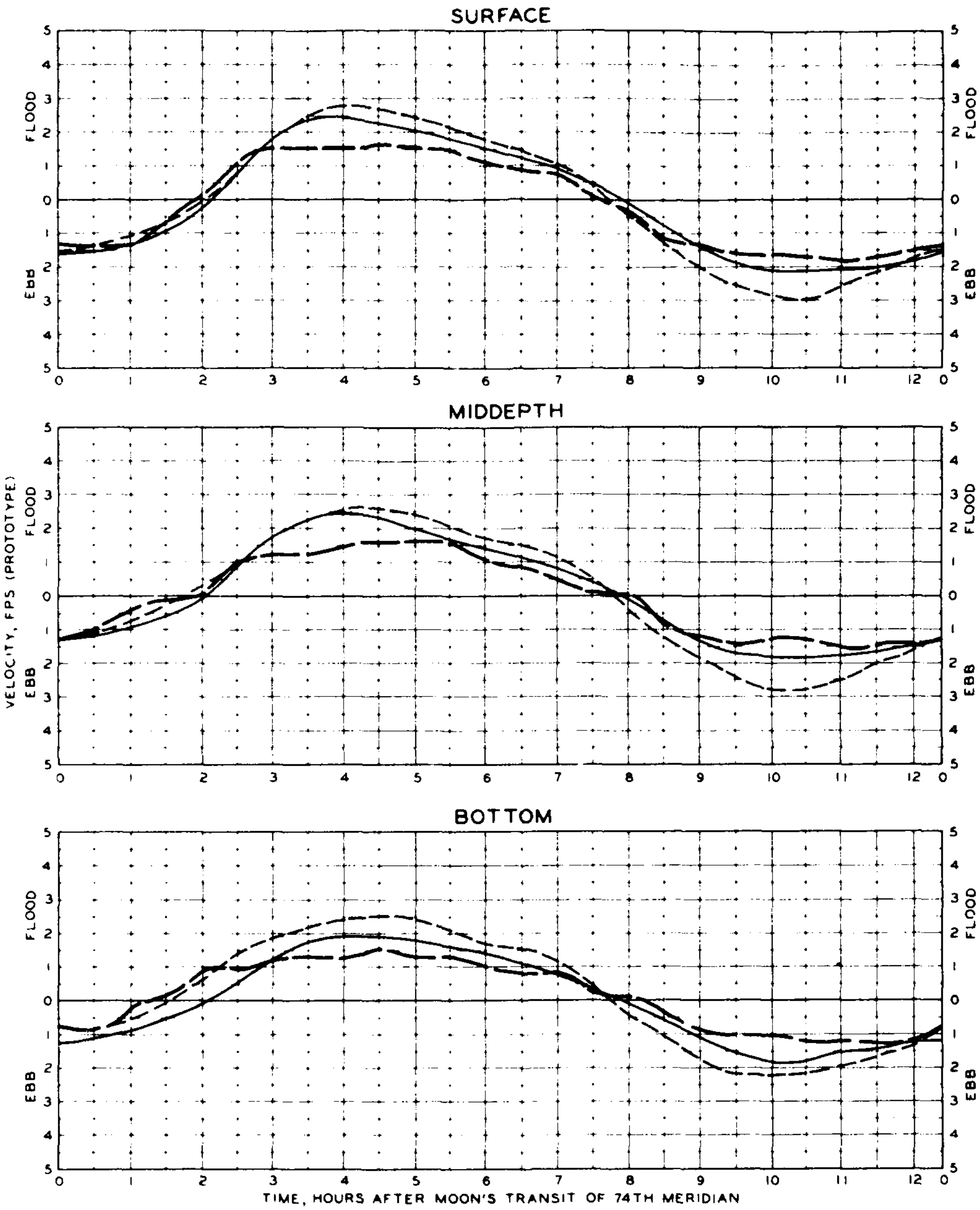
MODEL TEST DATA

TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— PROTOTYPE 1967
- - - - BASE TEST 1967
— — — BASE TEST 1974

VERIFICATION OF
CURRENT VELOCITIES
STATION 2V



MODEL TEST DATA

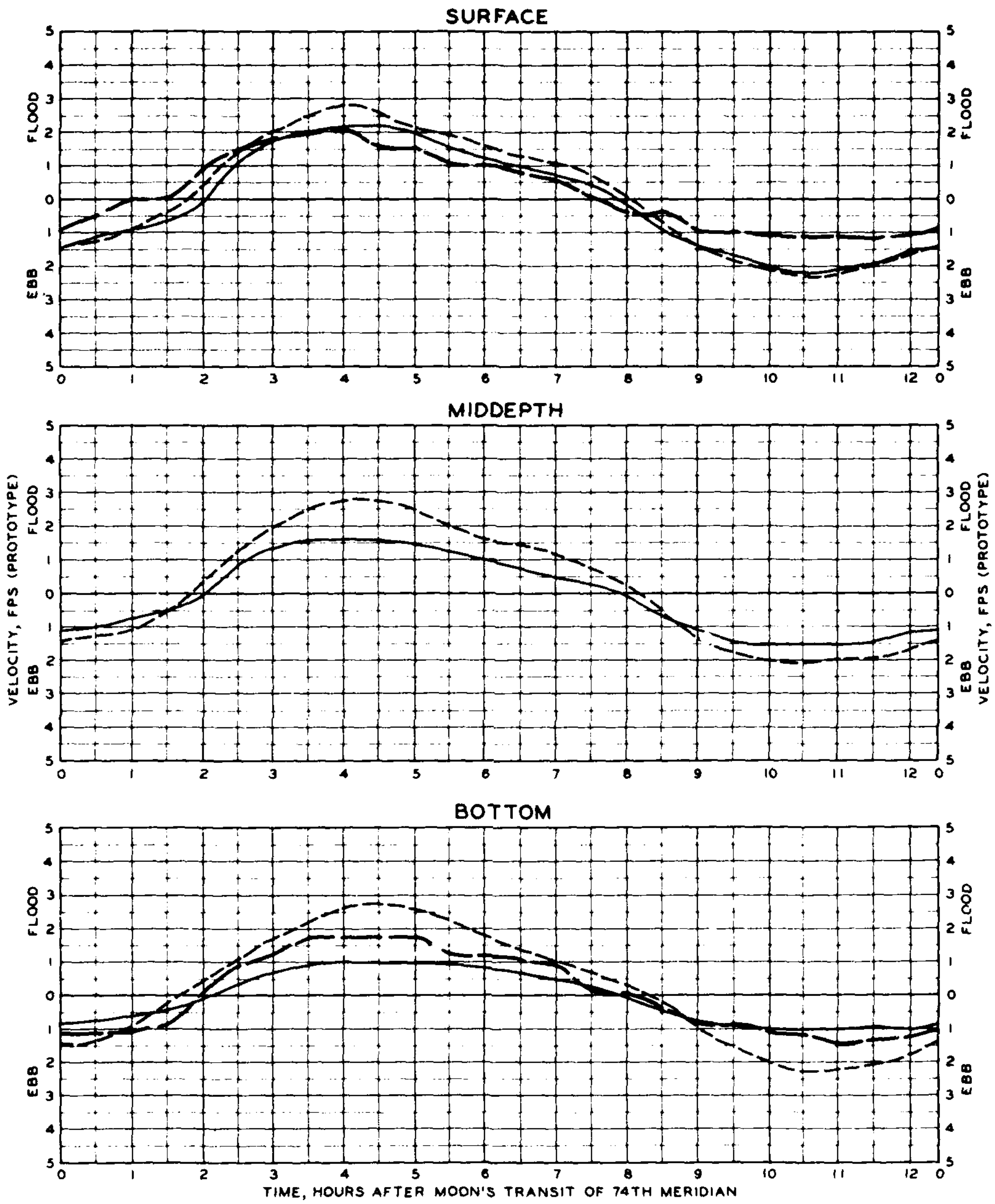
TIDE MEAN
FRESH WATER DISCHARGE
OCEAN SALINITY 30,000 PPM

LEGEND

—— PROTOTYPE 1967
- - - - BASE TEST 1967
— — — BASE TEST 1974

VERIFICATION OF CURRENT VELOCITIES

STATION 3V



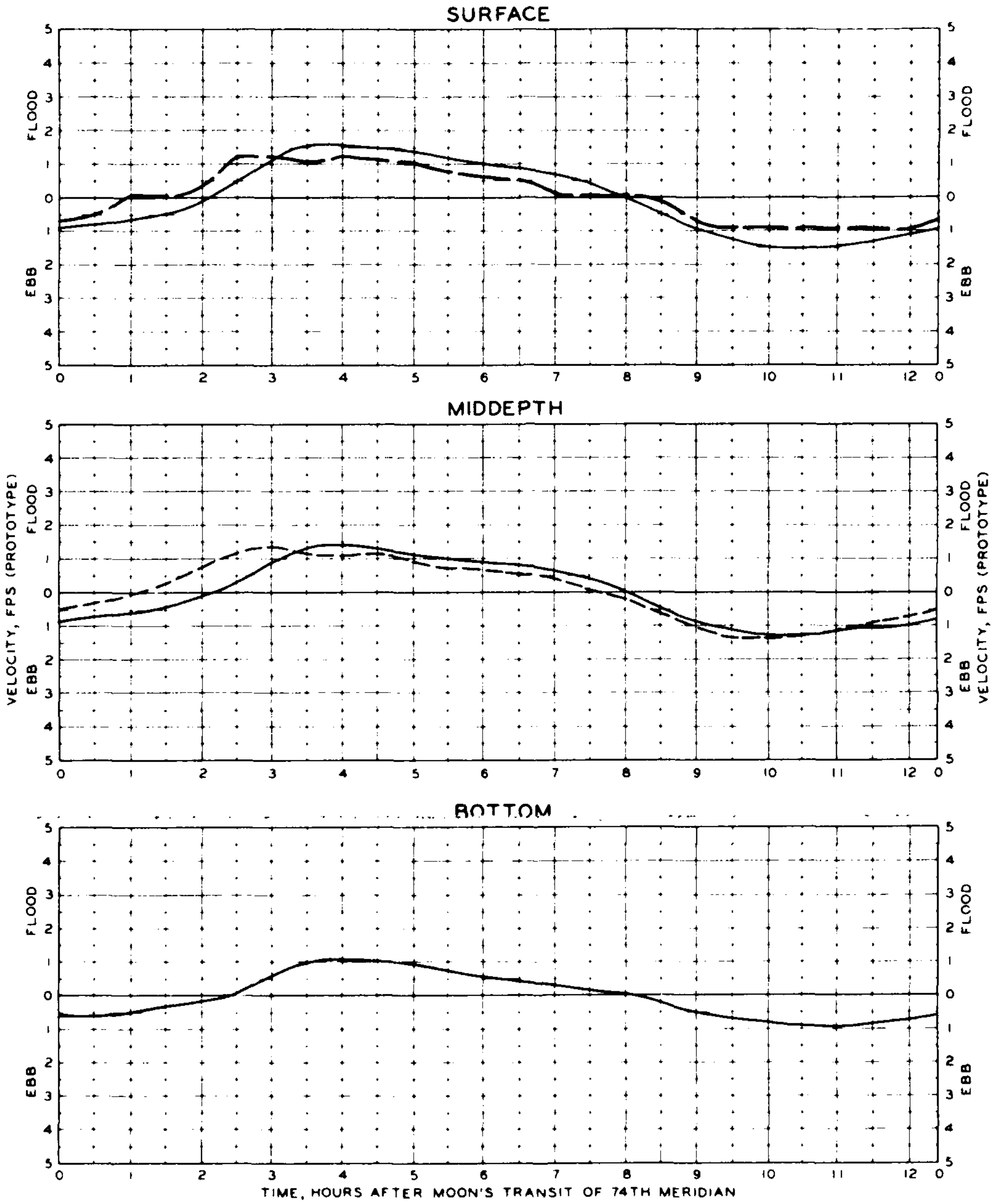
MODEL TEST DATA

TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

PROTOTYPE 1967
BASE TEST 1967
BASE TEST 1974

VERIFICATION OF
CURRENT VELOCITIES
STATION 4 V



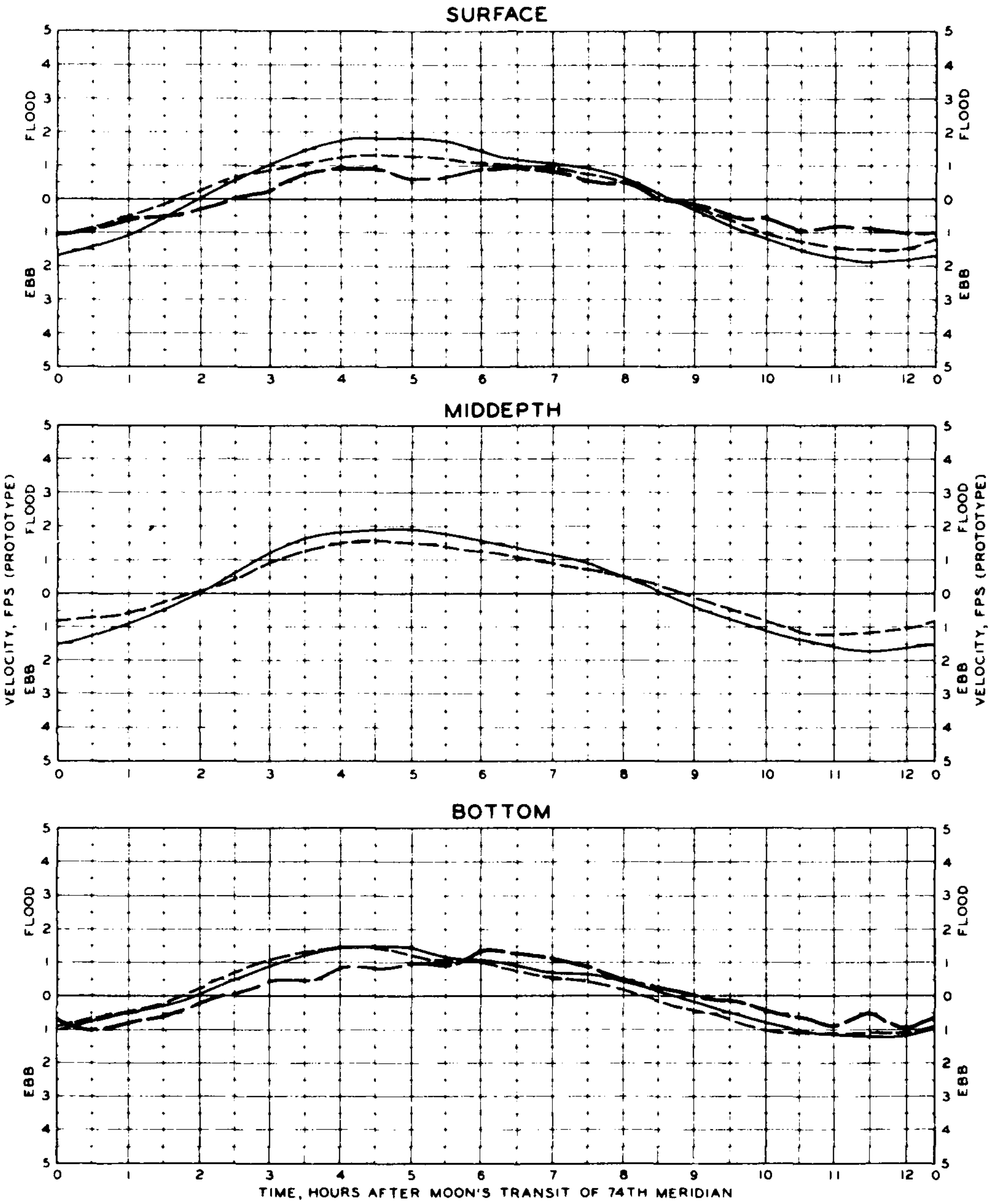
MODEL TEST DATA

TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

- ——— PROTOTYPE 1967
- - - - - BASE TEST 1967
- — — — BASE TEST 1974

VERIFICATION OF
CURRENT VELOCITIES
STATION 5 V



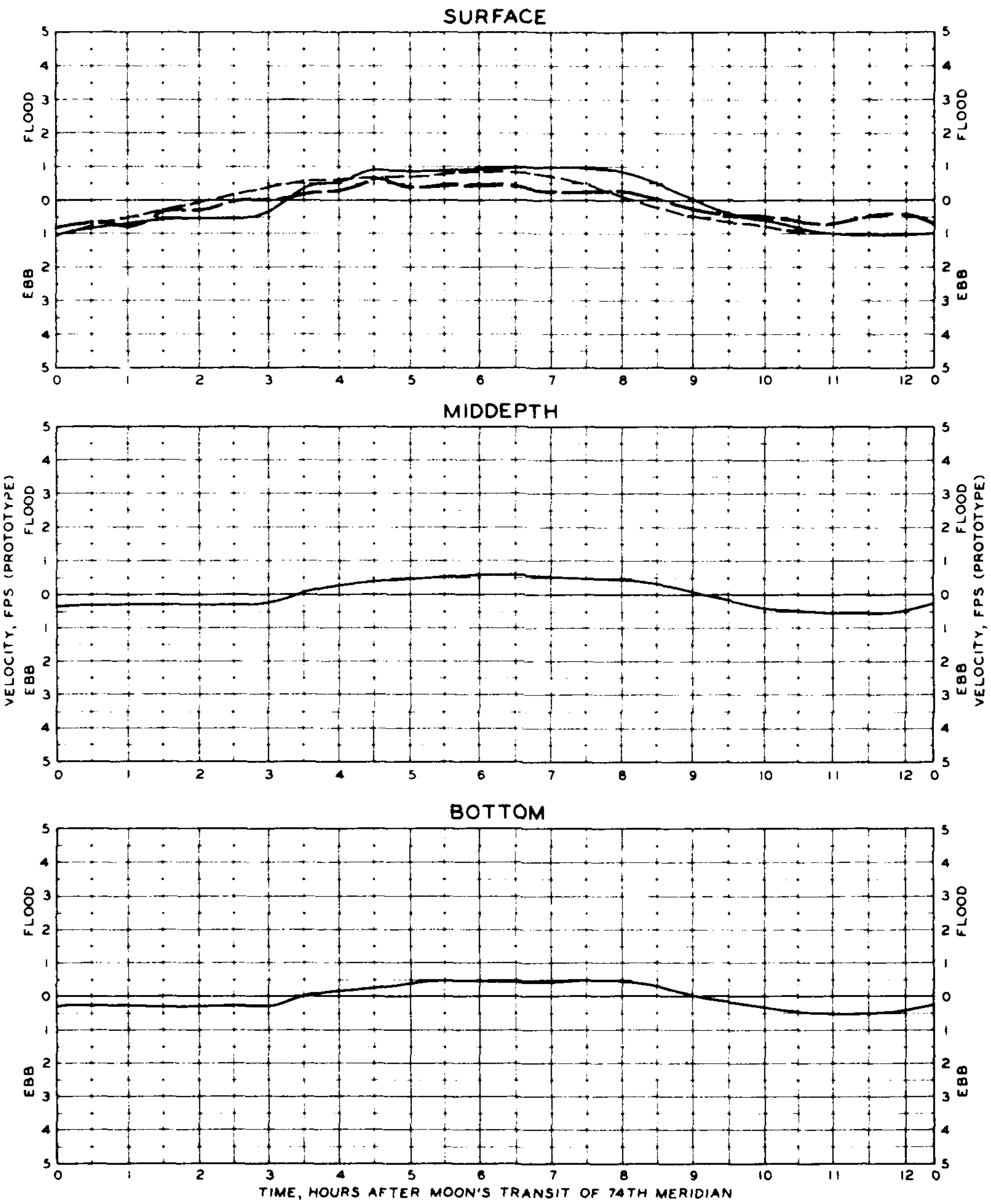
MODEL TEST DATA

TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

- ——— PROTOTYPE 1967
- - - - - BASE TEST 1967
- — — — BASE TEST 1974

VERIFICATION OF
CURRENT VELOCITIES
STATION 6 V



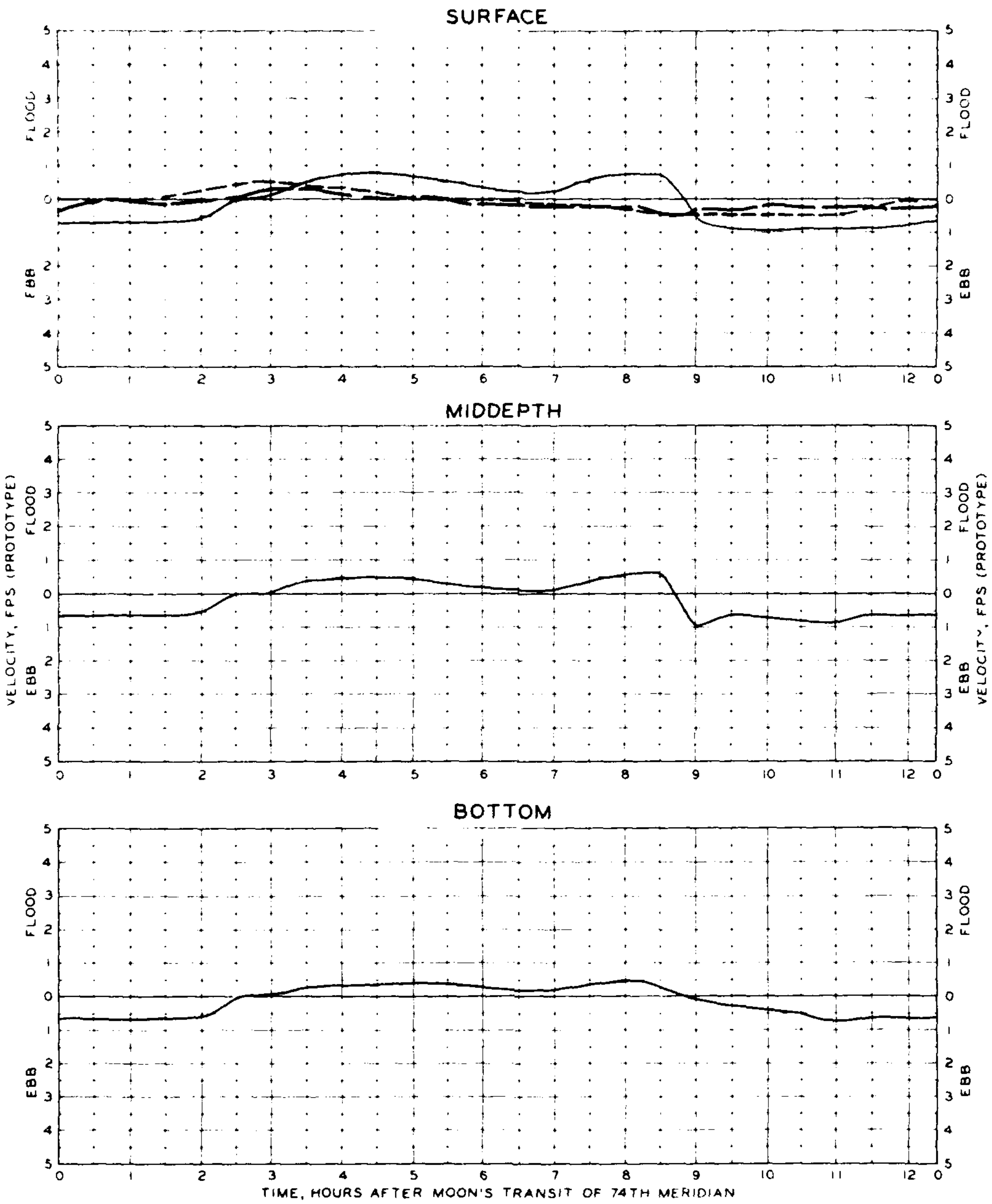
MODEL TEST DATA

TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— PROTOTYPE 1967
– – – – BASE TEST 1967
— - — BASE TEST 1974

VERIFICATION OF
CURRENT VELOCITIES
STATION 7 V



MODEL TEST DATA

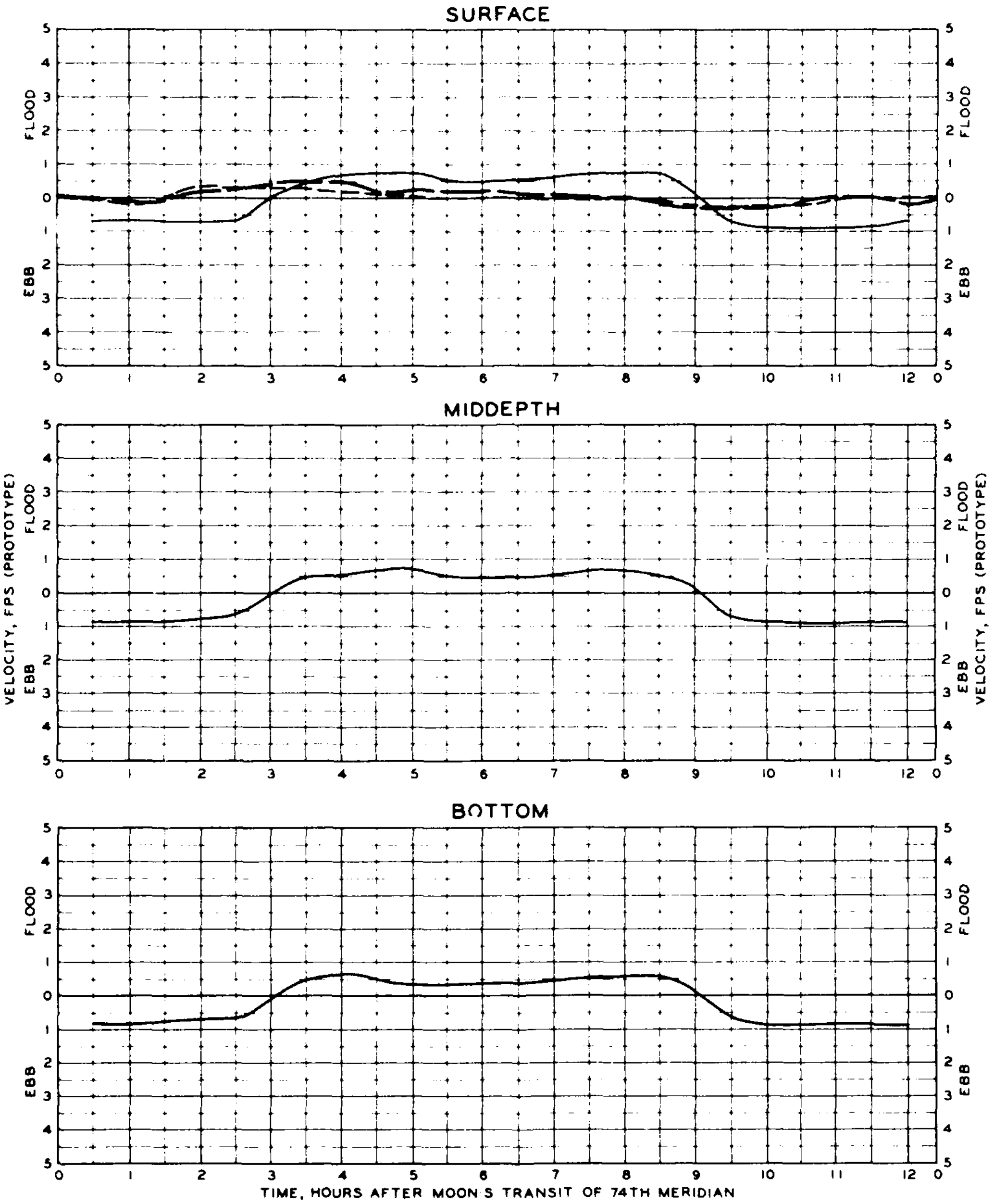
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— PROTOTYPE 1967
- - - - - BASE TEST 1967
— — — BASE TEST 1974

VERIFICATION OF CURRENT VELOCITIES

STATION 8V



MODEL TEST DATA

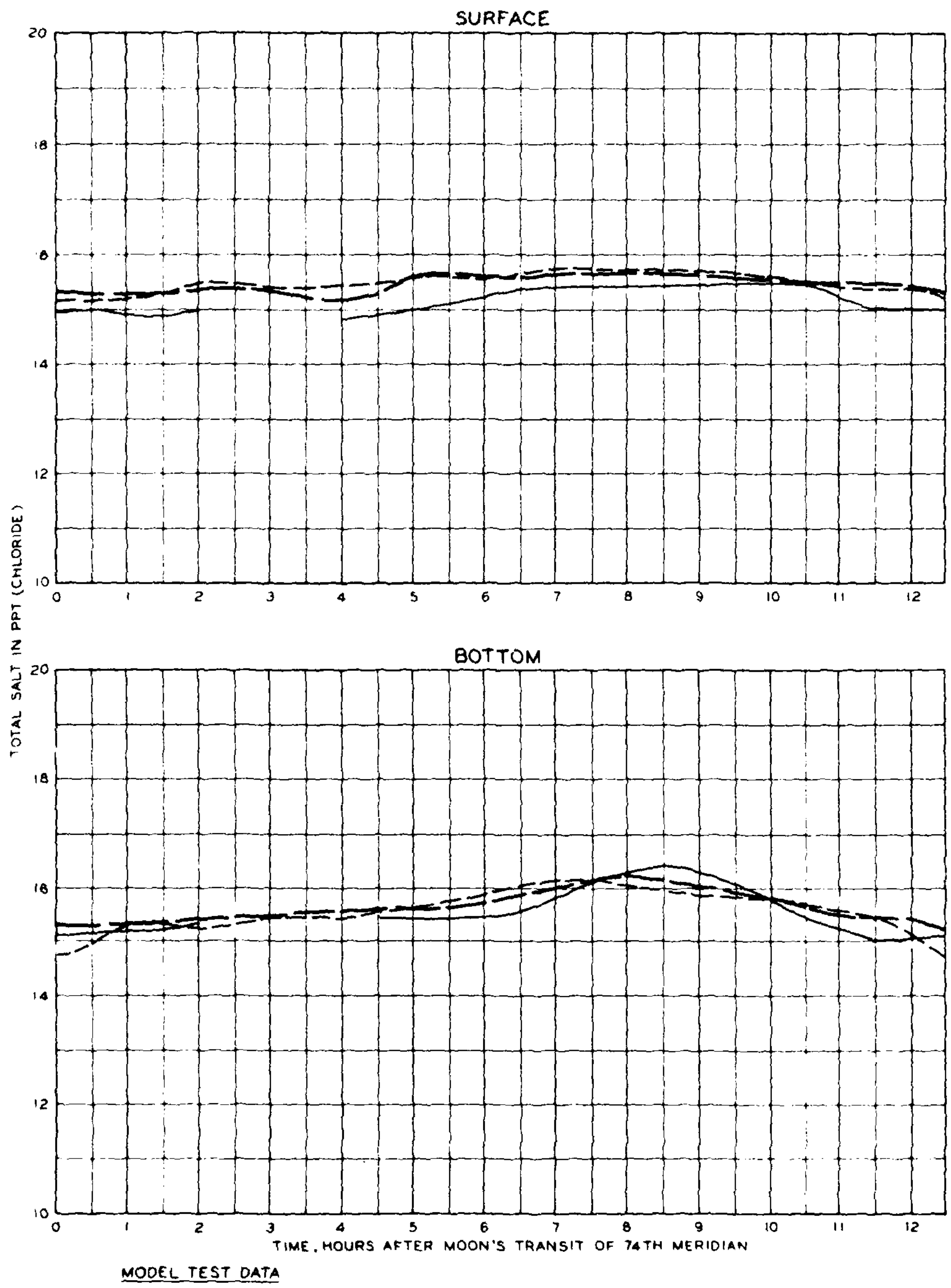
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— PROTOTYPE 1967
------ BASE TEST 1967
— — — BASE TEST 1974

VERIFICATION OF CURRENT VELOCITIES

STATION 9 V



MODEL TEST DATA

TIDE MEAN
FRESH WATER DISCHARGE
OCEAN SALINITY 30,000 PPM

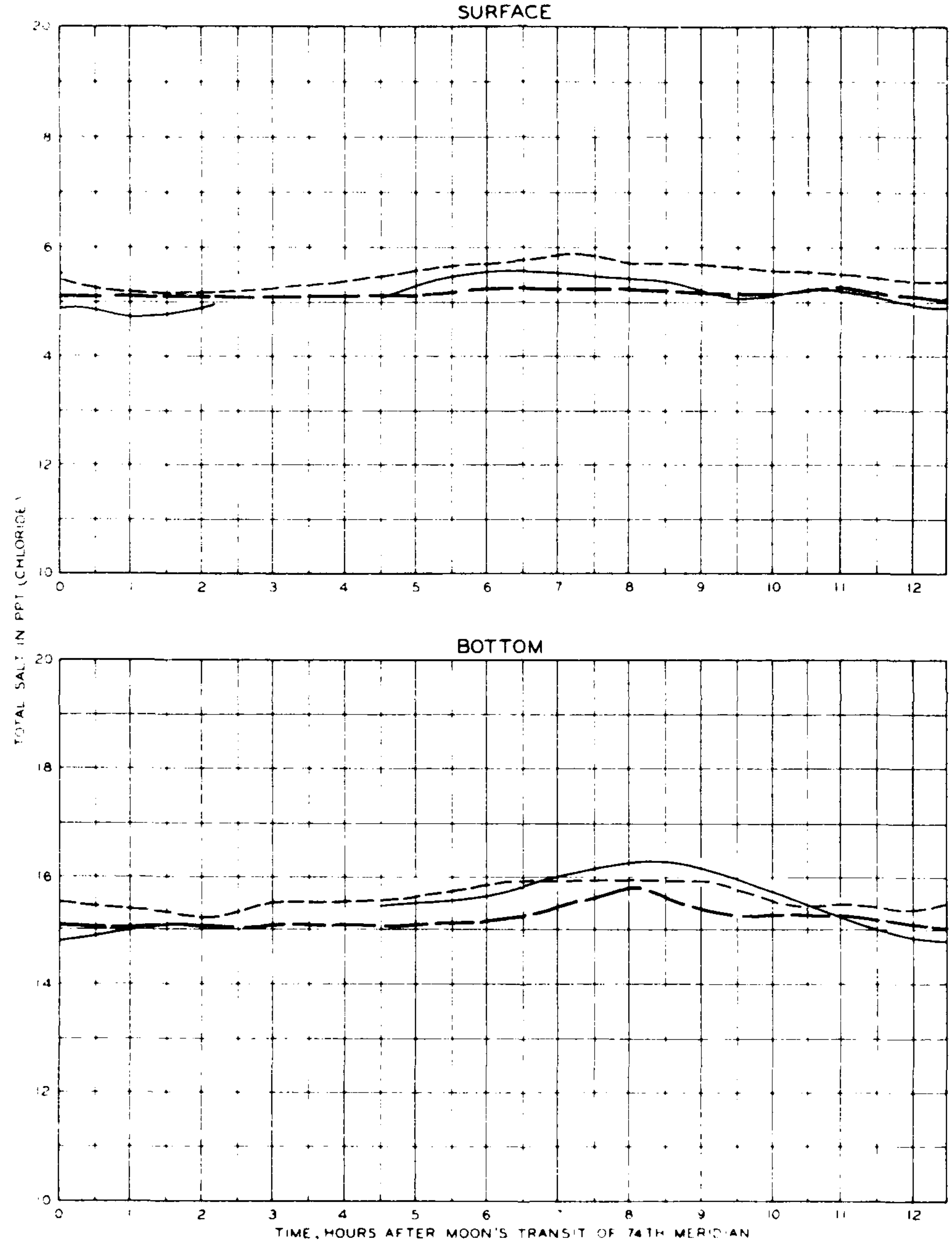
LEGEND

PROTOTYPE 1967
BASE TEST 1967
BASE TEST 1974

VERIFICATION OF SALINITIES

STATION IV

PLATE 16



MODEL TEST DATA

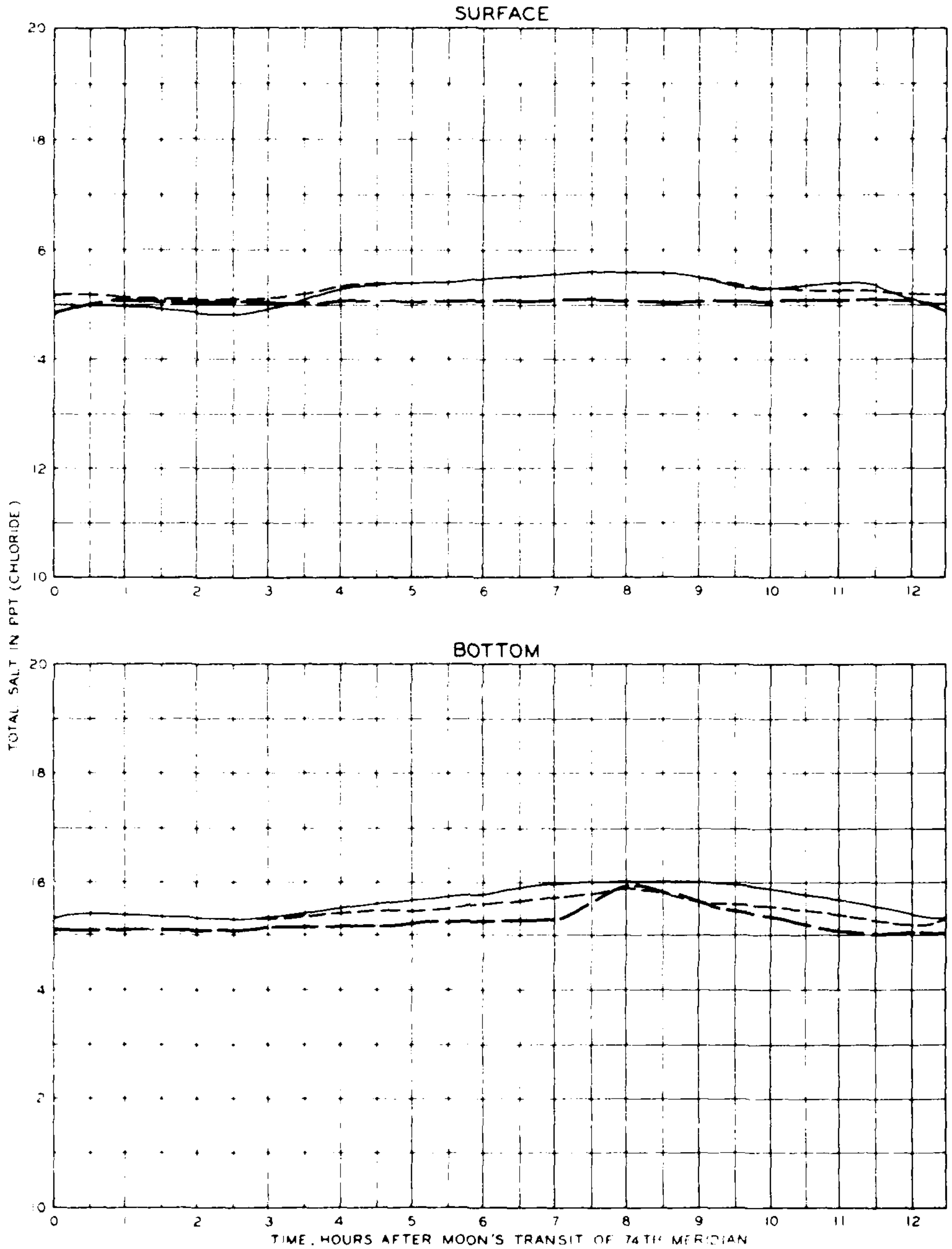
TIDE MEAN
FRESH WATER DISCHARGE
OCEAN SALINITY 30,000 PPM

LEGEND

PROTOTYPE 1967
BASE TEST 1967
BASE TEST 1974

VERIFICATION OF SALINITIES

STATION 2 V



MODEL TEST DATA

TIDE MEAN
FRESH WATER DISCHARGE
OCEAN SALINITY 30,000 PPM

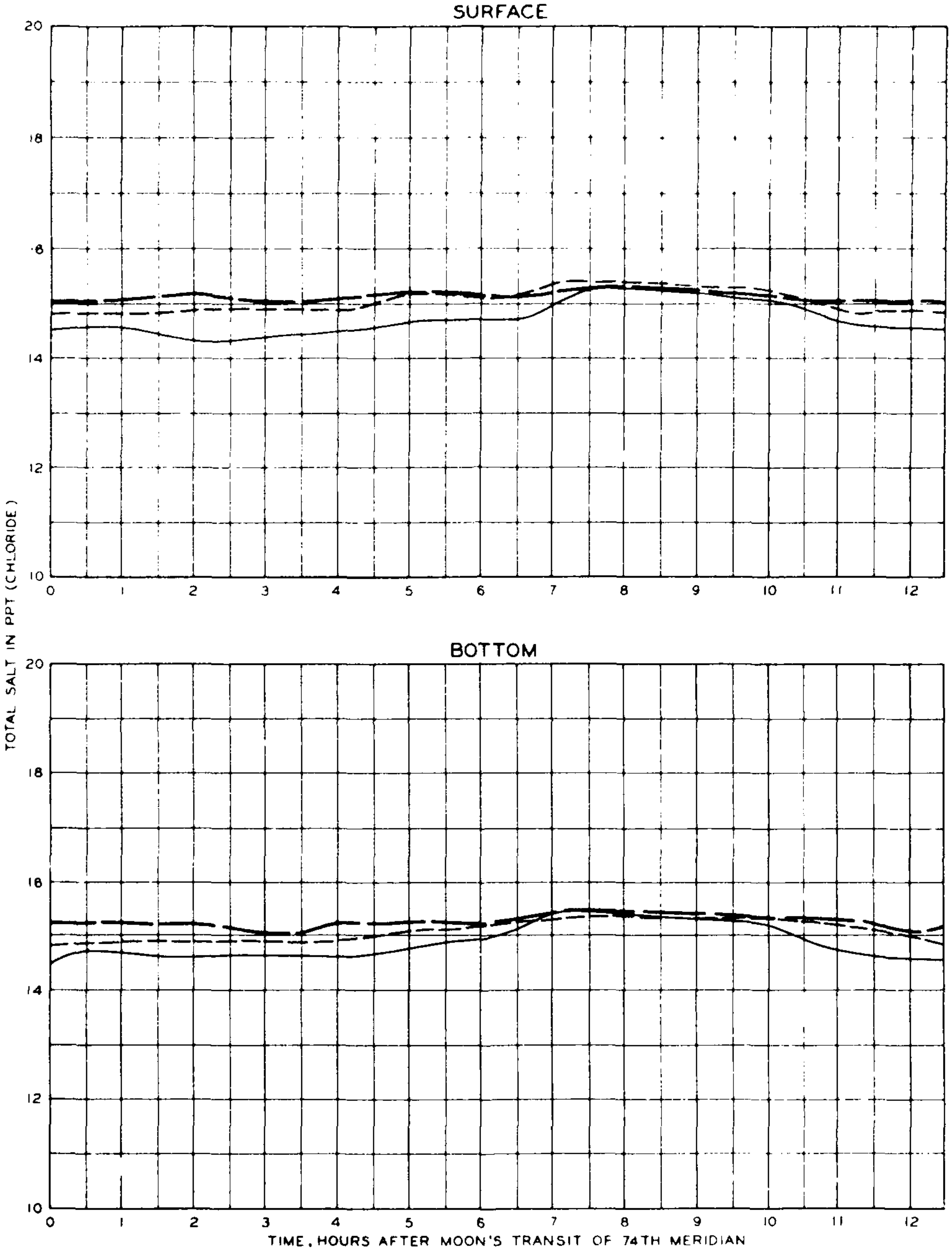
LEGEND

——— PROTOTYPE 1967
- - - - - BASE TEST 1967
— — — BASE TEST 1974

VERIFICATION OF SALINITIES

STATION 3V

PLATE 18



MODEL TEST DATA

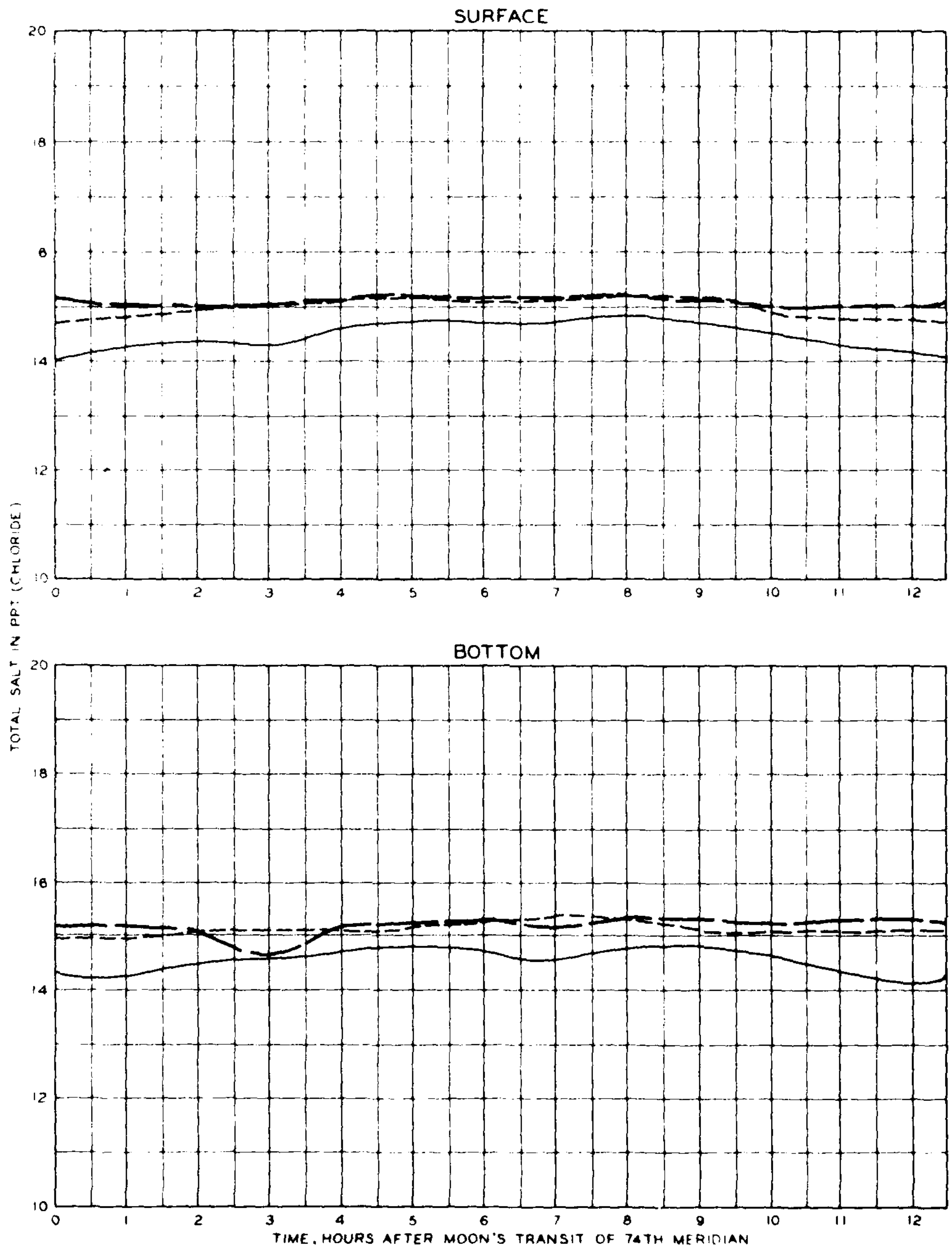
TIDE MEAN
FRESH WATER DISCHARGE ..
OCEAN SALINITY 30,000 PPM

LEGEND

——— PROTOTYPE 1967
- - - - - BASE TEST 1967
— — — BASE TEST 1974

VERIFICATION OF SALINITIES

STATION 4 V



MODEL TEST DATA

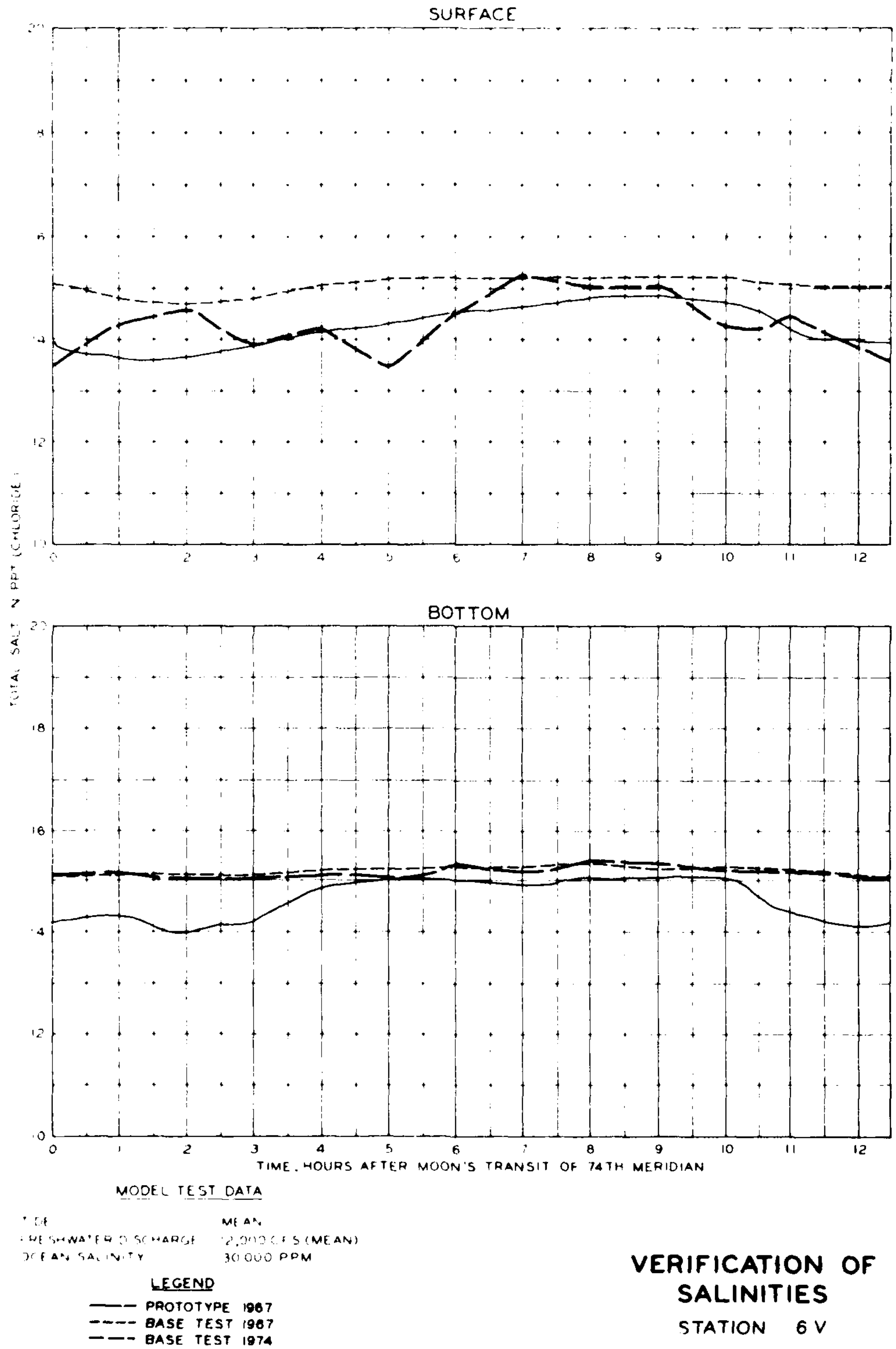
TIDE MEAN
FRESH WATER DISCHARGE
OCEAN SALINITY 30,000 PPM

LEGEND

—— PROTOTYPE 1967
- - - - BASE TEST 1967
— - — BASE TEST 1974

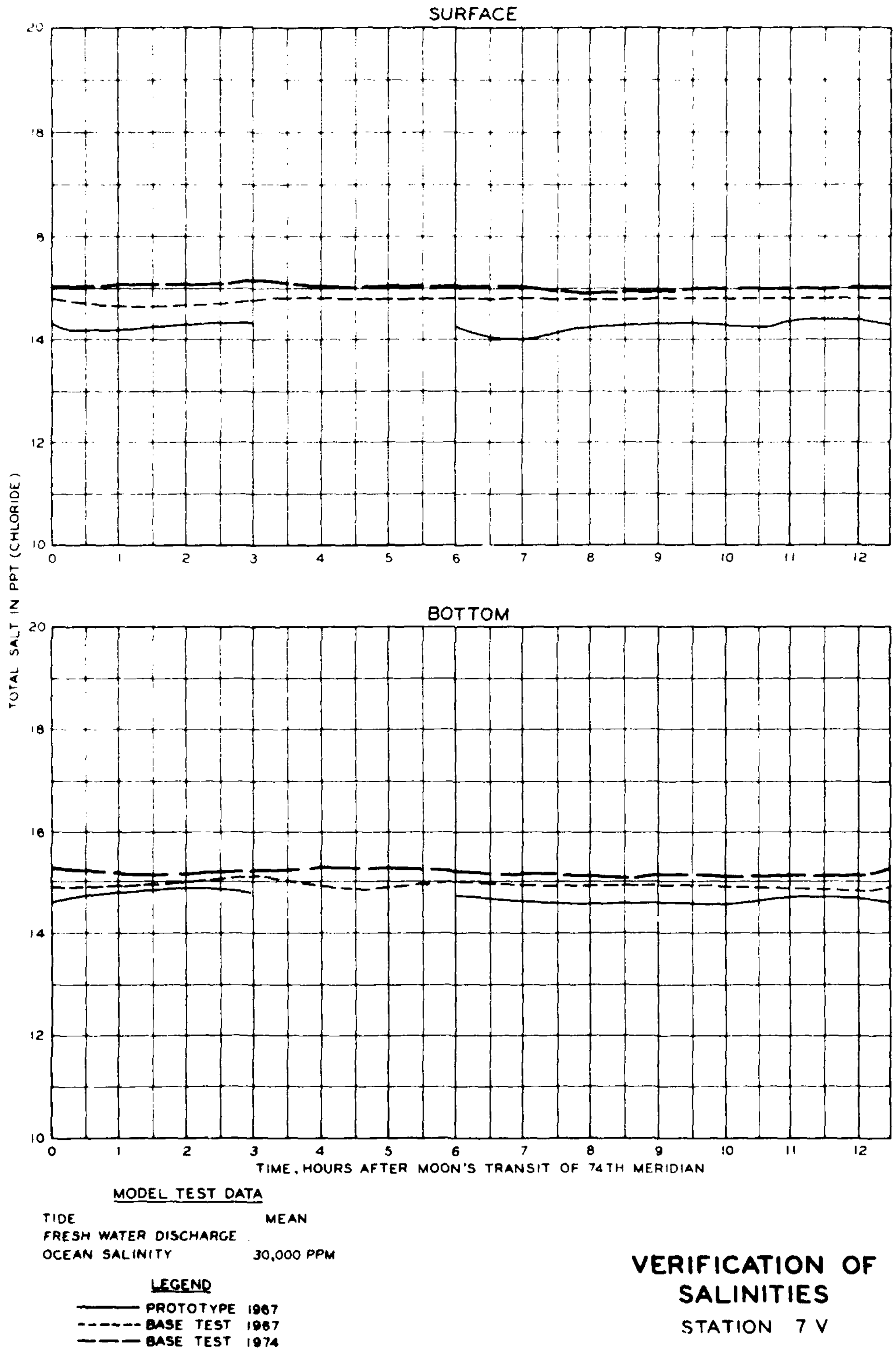
VERIFICATION OF SALINITIES

STATION 5 V



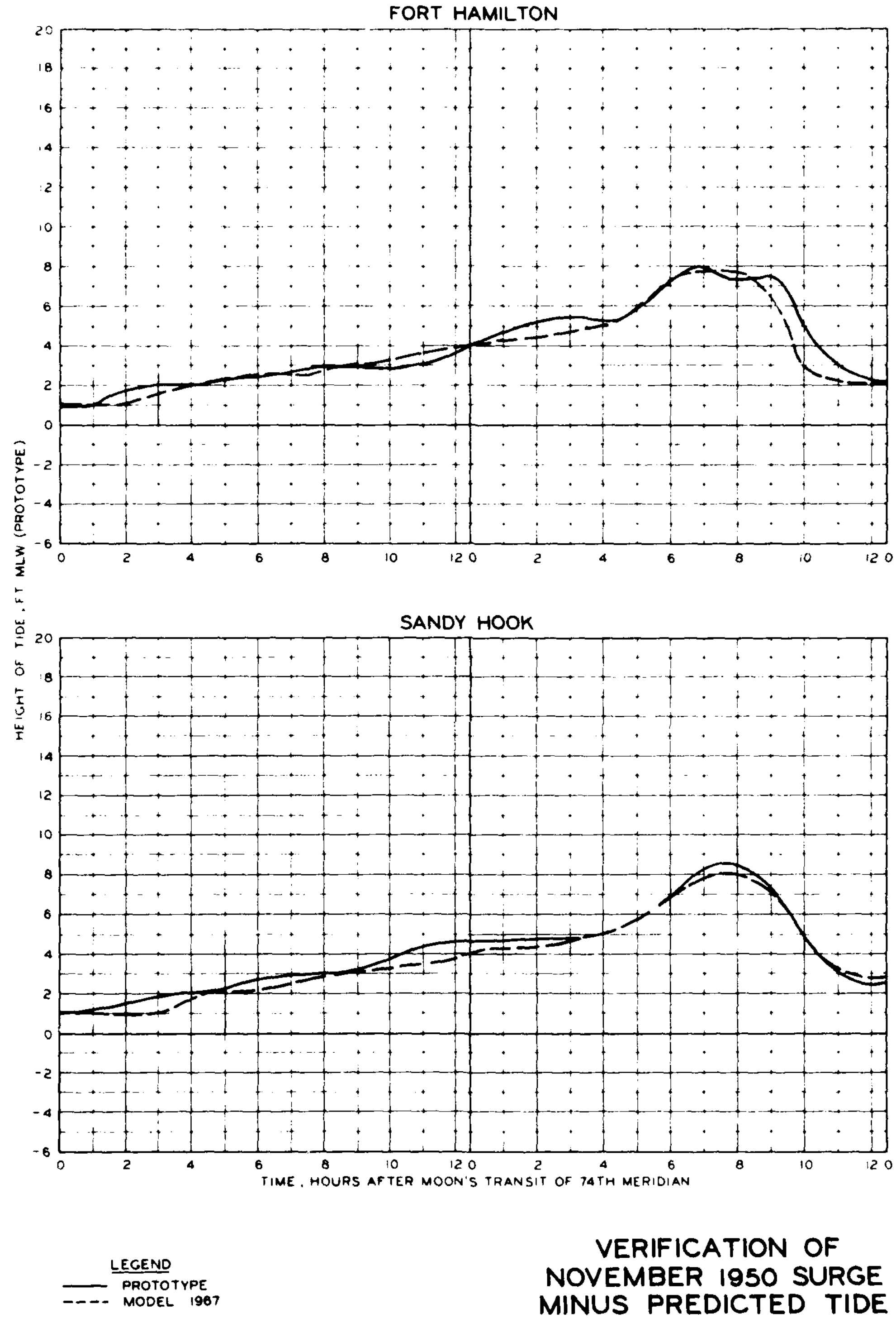
VERIFICATION OF SALINITIES

STATION 6 V



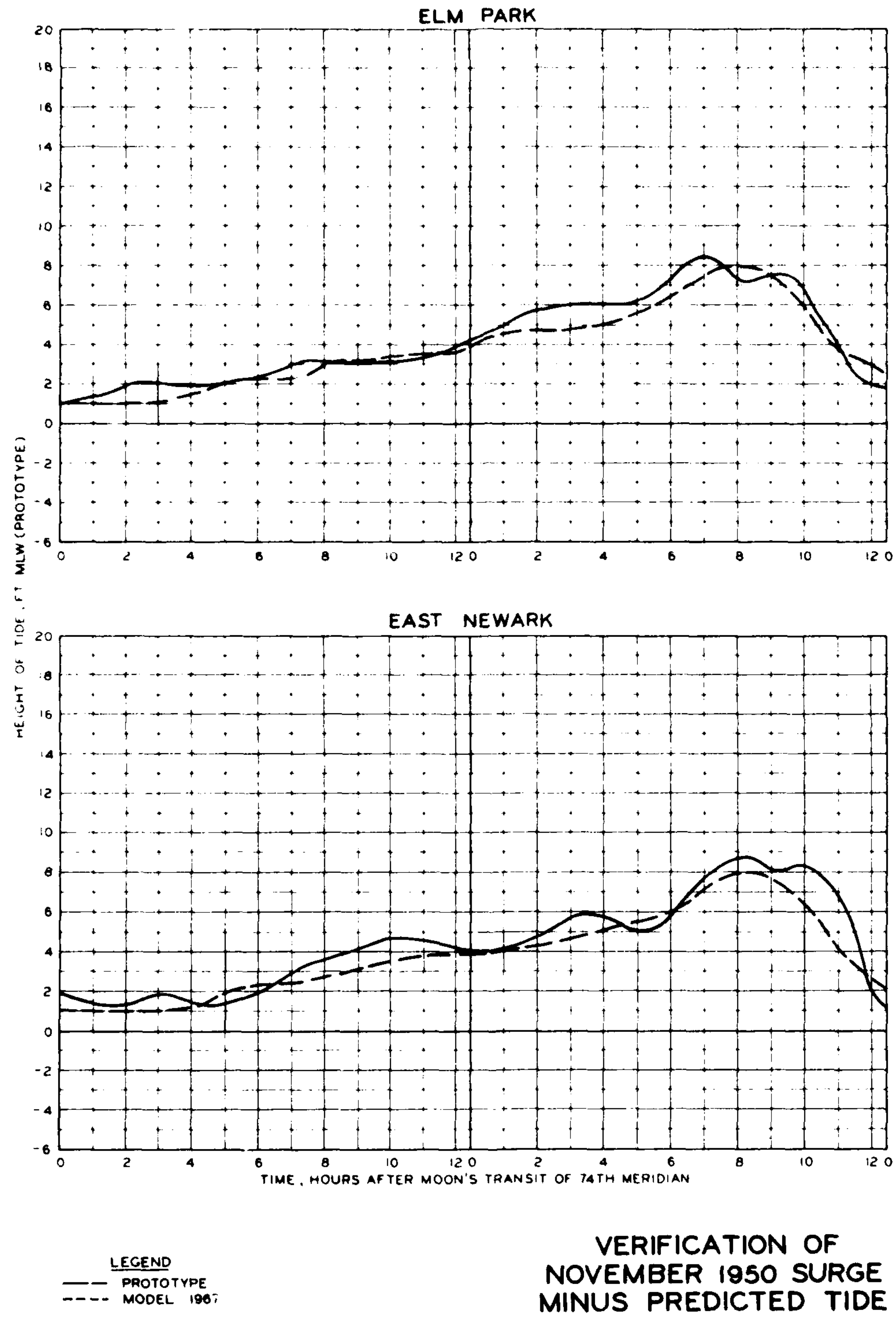
VERIFICATION OF SALINITIES

STATION 7 V



VERIFICATION OF NOVEMBER 1950 SURGE MINUS PREDICTED TIDE

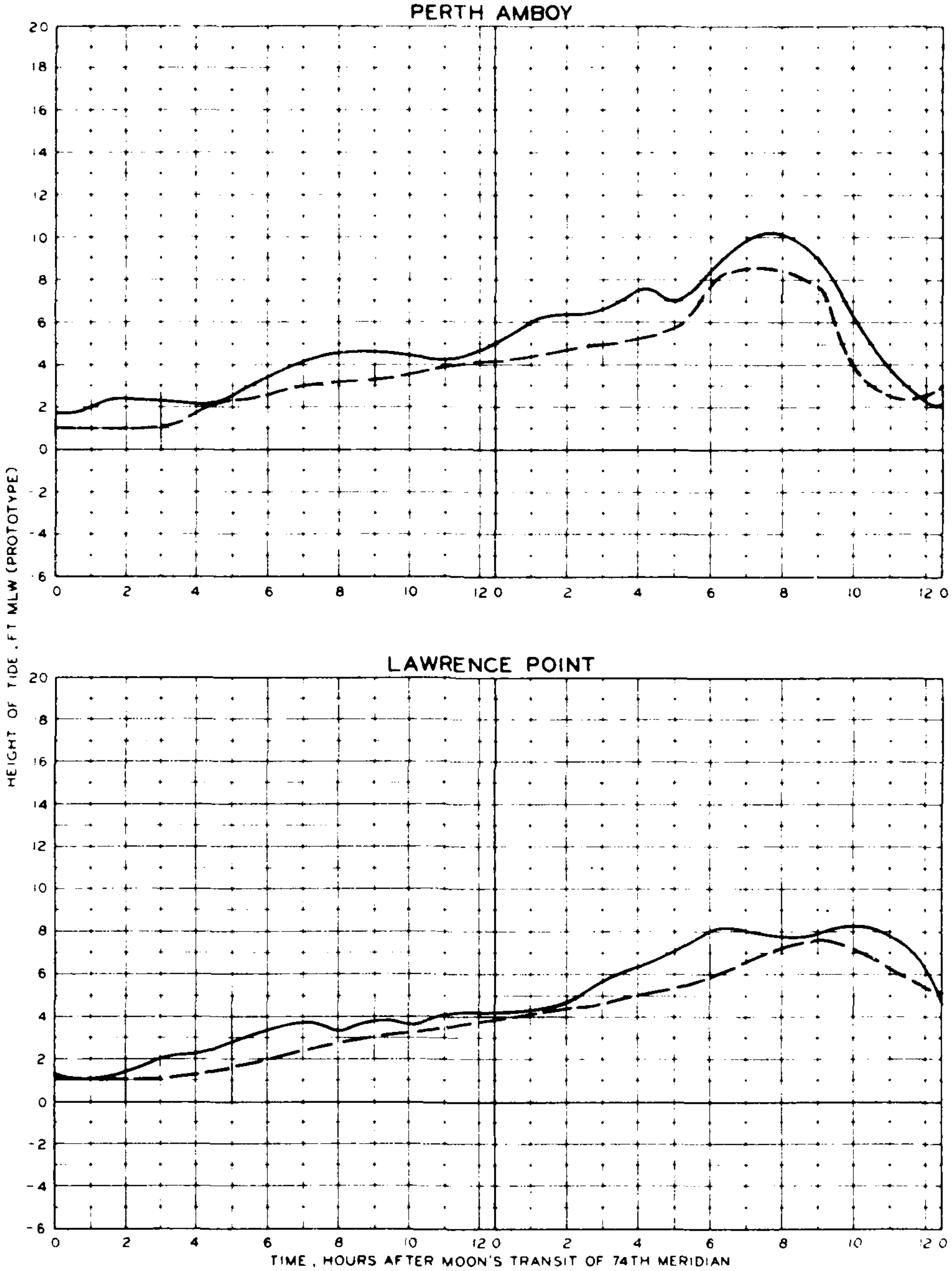
FORT HAMILTON AND SANDY HOOK



VERIFICATION OF
NOVEMBER 1950 SURGE
MINUS PREDICTED TIDE

ELM PARK AND
EAST NEWARK

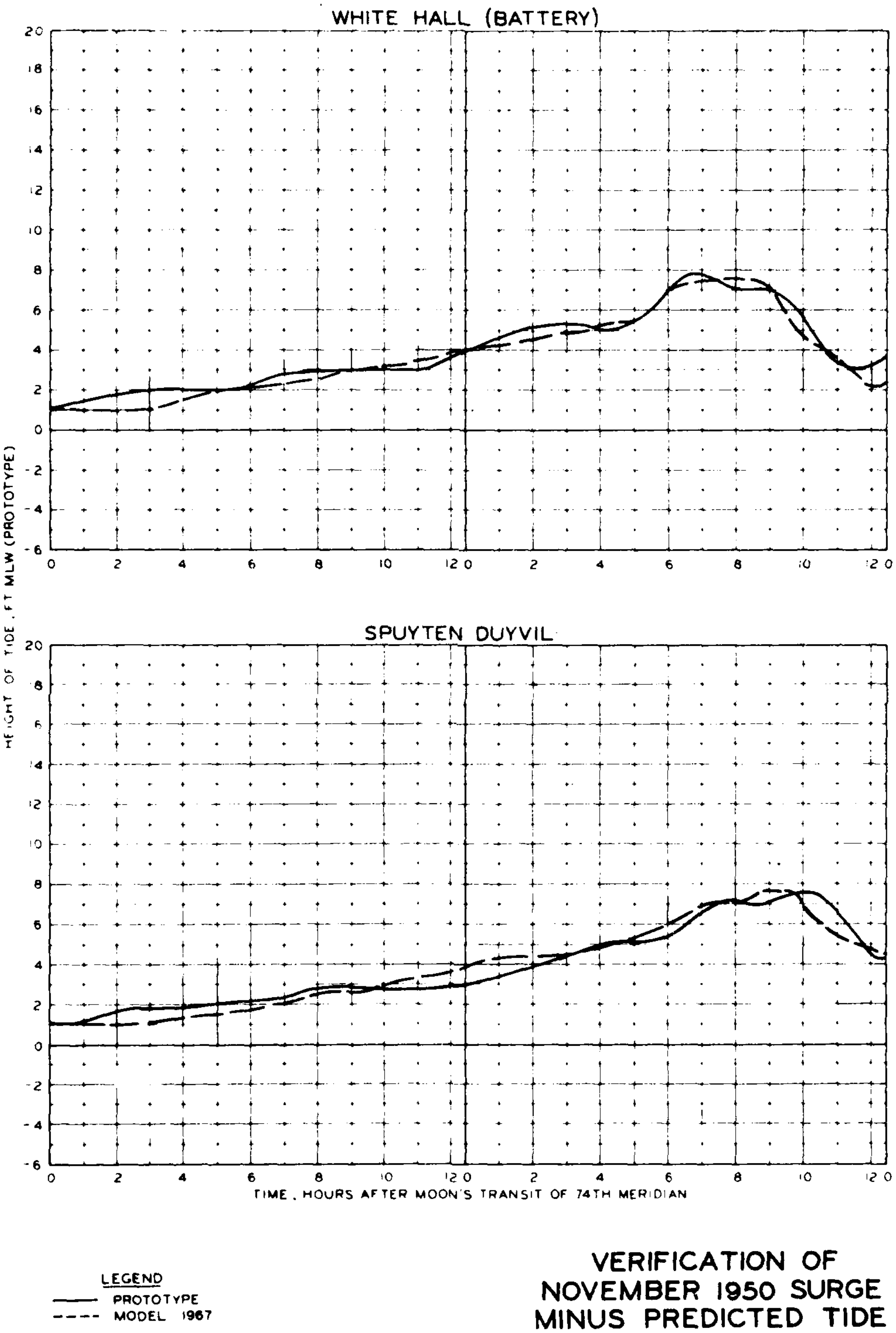
PLATE 24



LEGEND
—— PROTOTYPE
---- MODEL 1967

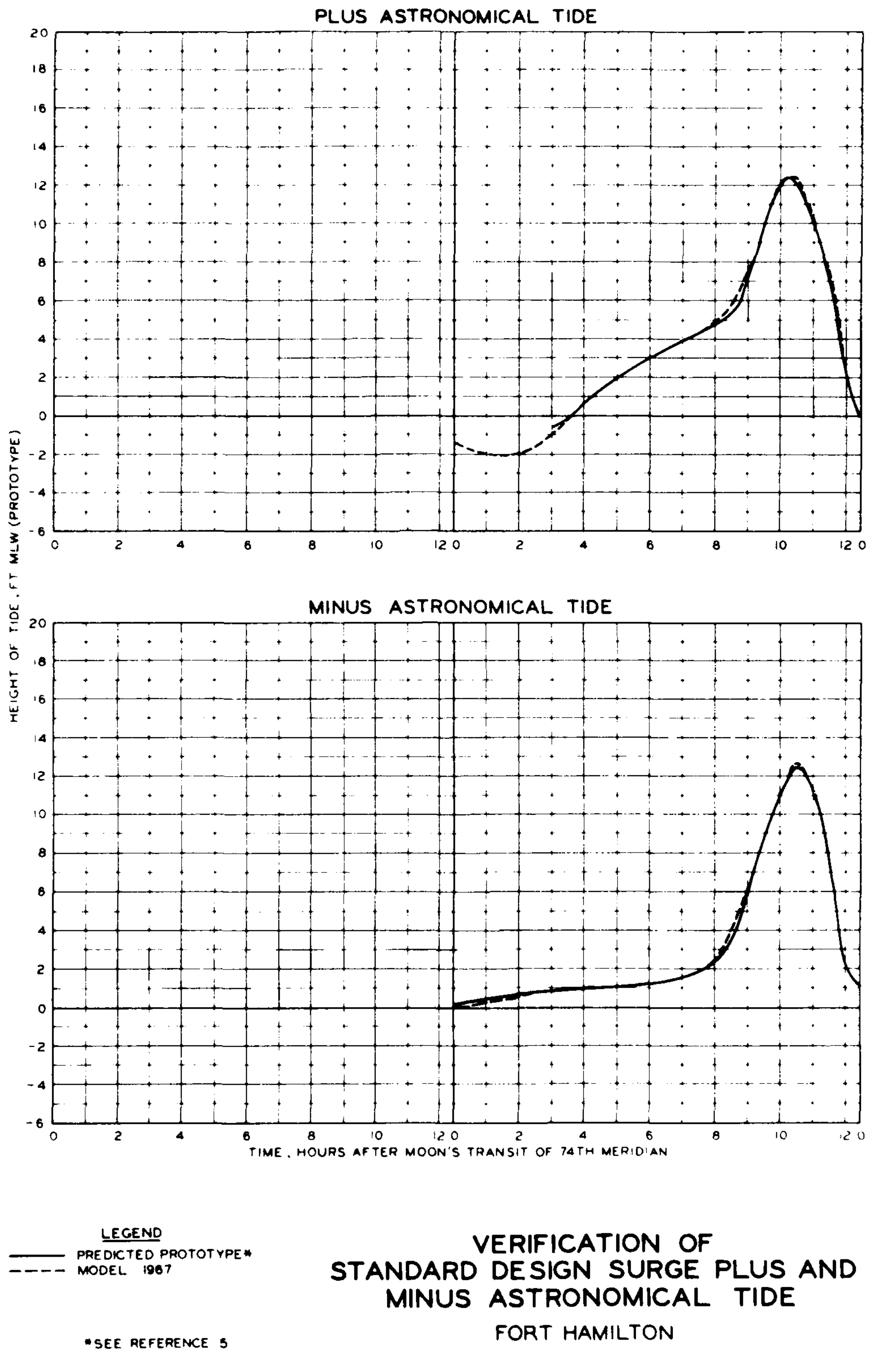
VERIFICATION OF NOVEMBER 1950 SURGE MINUS PREDICTED TIDE

PERTH AMBOY AND LAWRENCE POINT



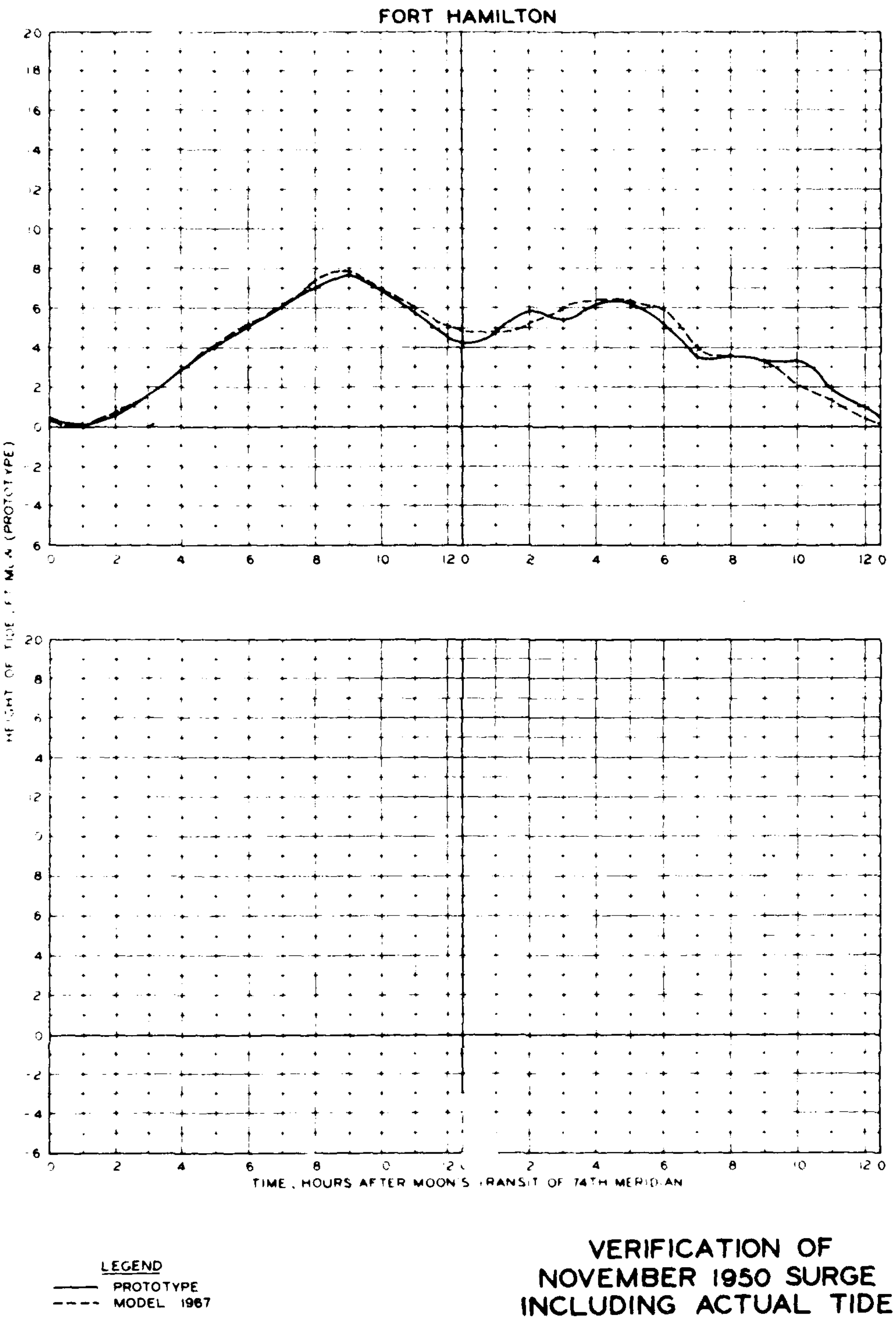
VERIFICATION OF NOVEMBER 1950 SURGE MINUS PREDICTED TIDE

WHITE HALL (BATTERY)
AND SPUYTEN DUYVIL

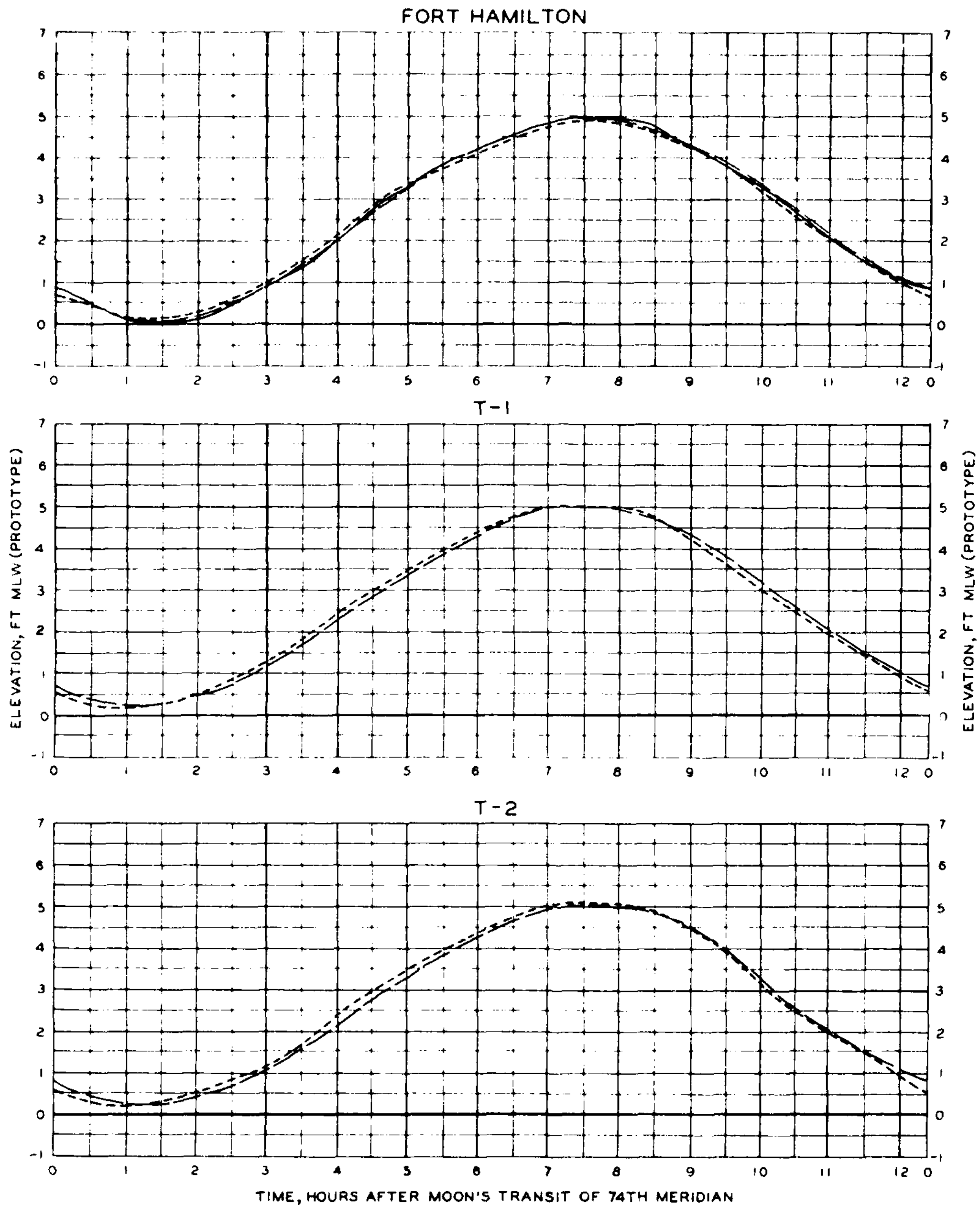


VERIFICATION OF STANDARD DESIGN SURGE PLUS AND MINUS ASTRONOMICAL TIDE

FORT HAMILTON



VERIFICATION OF
NOVEMBER 1950 SURGE
INCLUDING ACTUAL TIDE
FORT HAMILTON



MODEL TEST DATA

TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

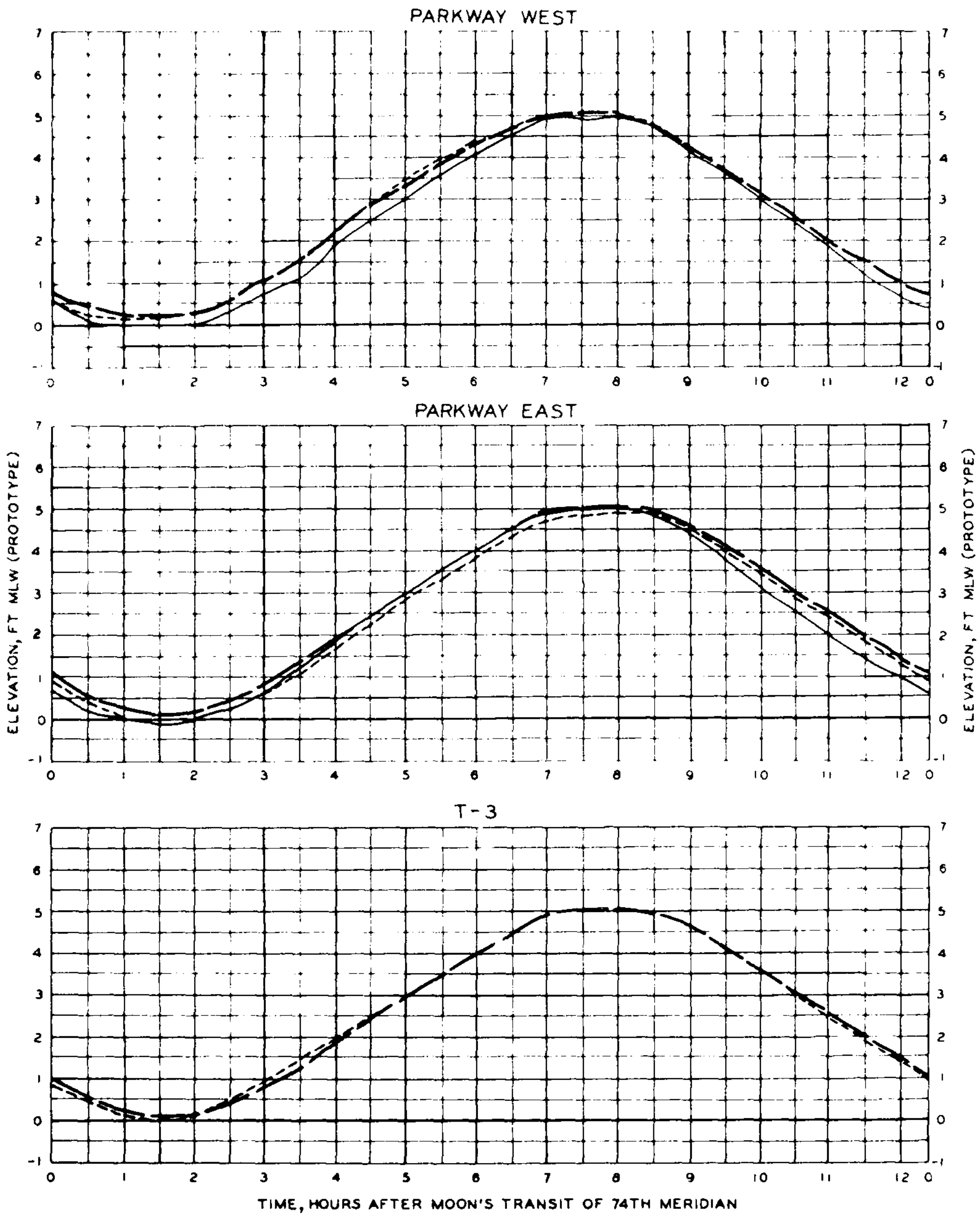
- ——— BASE TEST 1967
- - - - - PLAN 3
- — — PLAN 6

TIDAL HEIGHTS

PLANS 3 AND 6

STATIONS FORT HAMILTON, T-1, AND T-2

PLATE 29



MODEL TEST DATA

TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

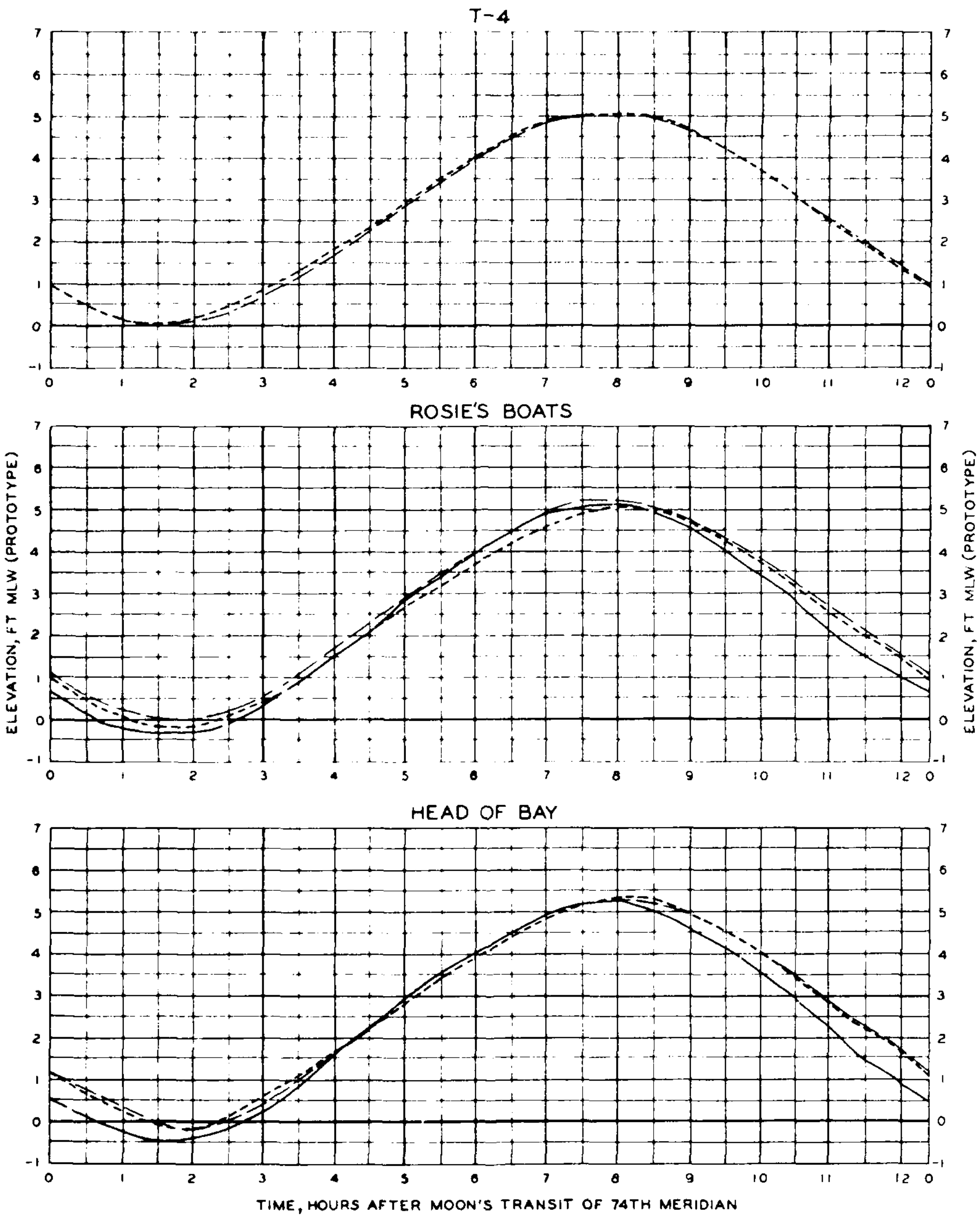
LEGEND

——— BASE TEST 1967
------ PLAN 3
— — — PLAN 6

TIDAL HEIGHTS

PLANS 3 AND 6

STATIONS PARKWAY WEST, PARKWAY EAST, AND T-3



MODEL TEST DATA

TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

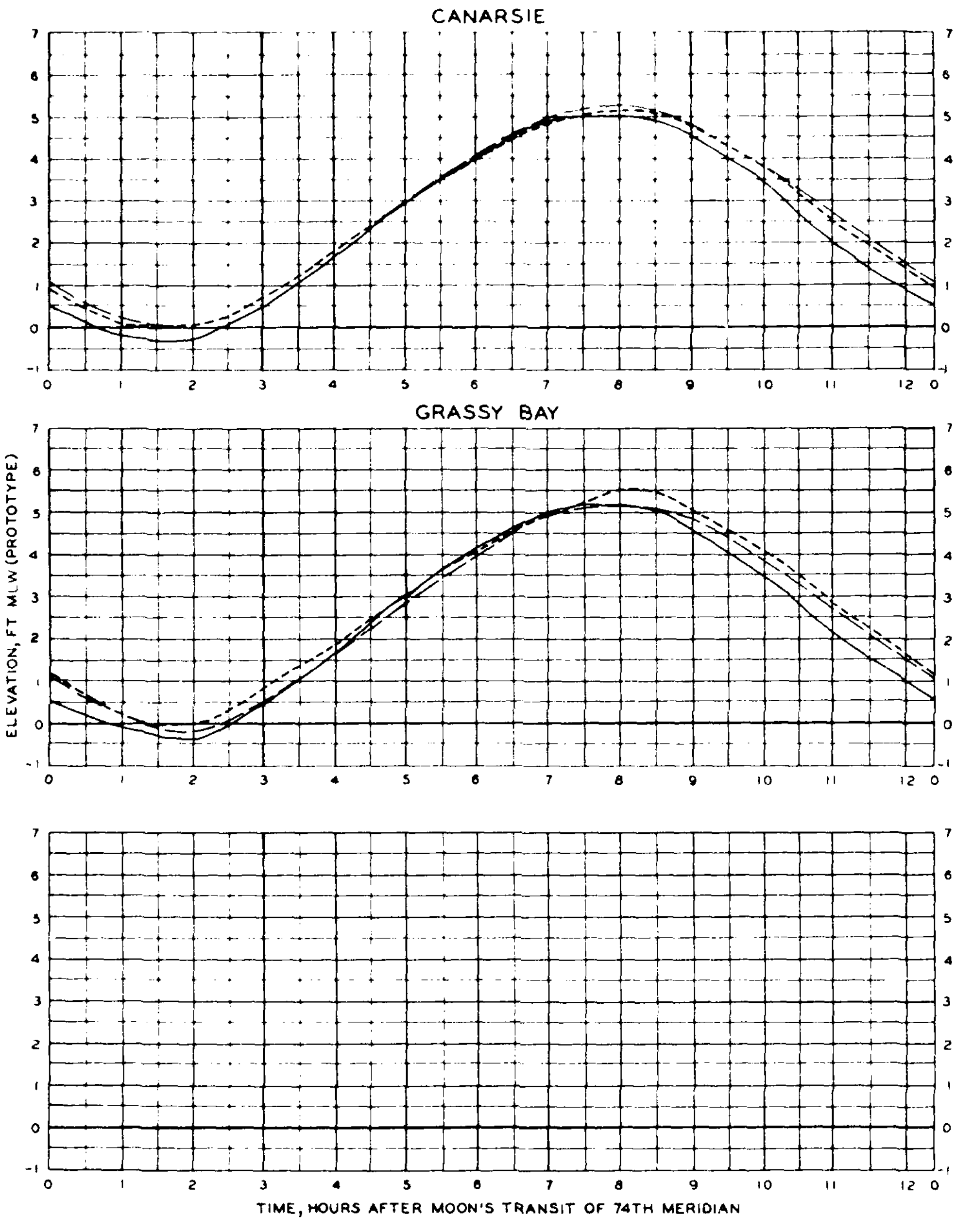
LEGEND

- ——— BASE TEST 1967
- - - - - - PLAN 3
- — — — PLAN 6

TIDAL HEIGHTS

PLANS 3 AND 6

STATIONS T-4, ROSIE'S BOAT, AND HEAD OF BAY



MODEL TEST DATA

TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

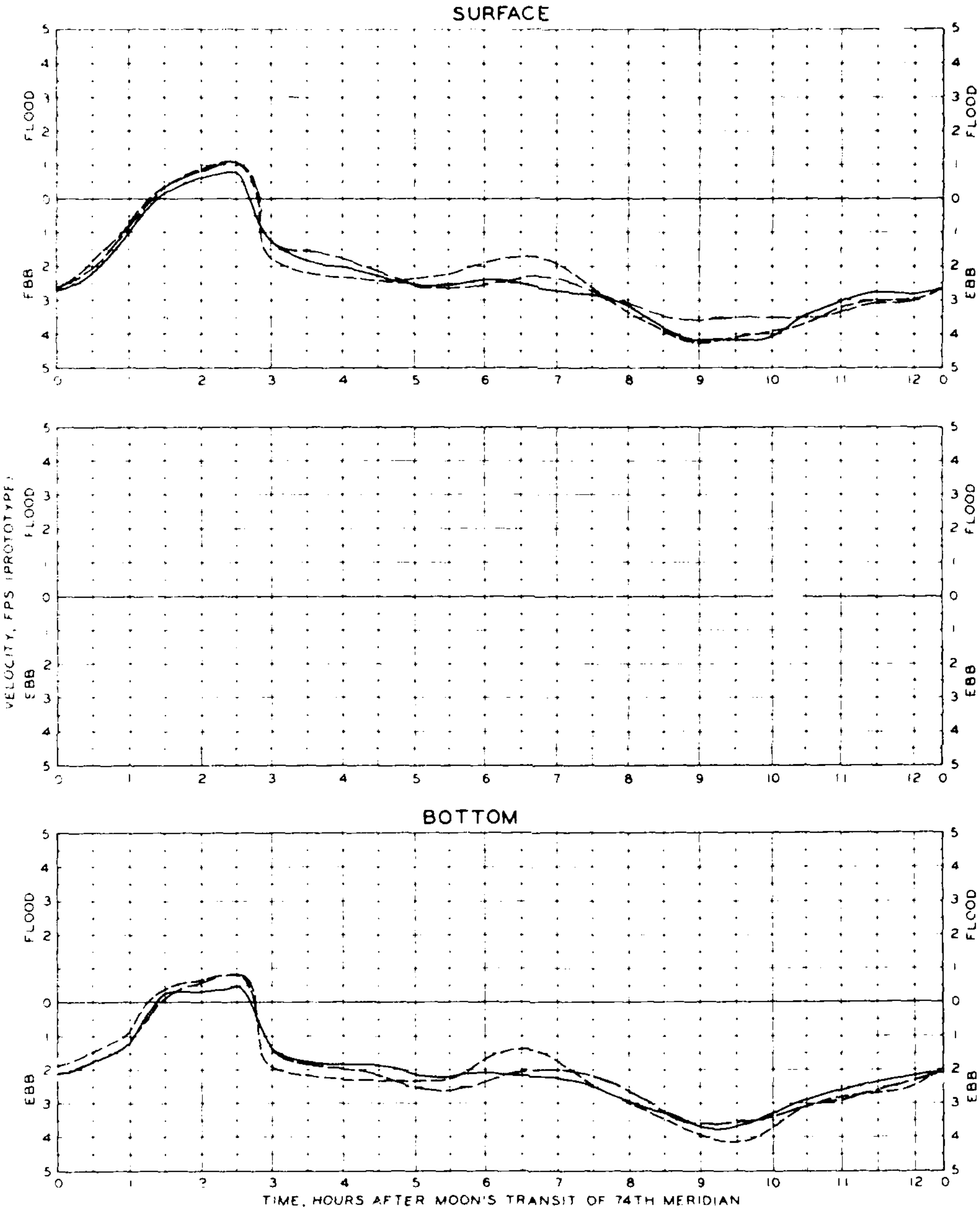
LEGEND

——— BASE TEST 1967
------ PLAN 3
— — — PLAN 6

TIDAL HEIGHTS

PLANS 3 AND 6

STATIONS CANARSIE AND GRASSY BAY



MODEL TEST DATA

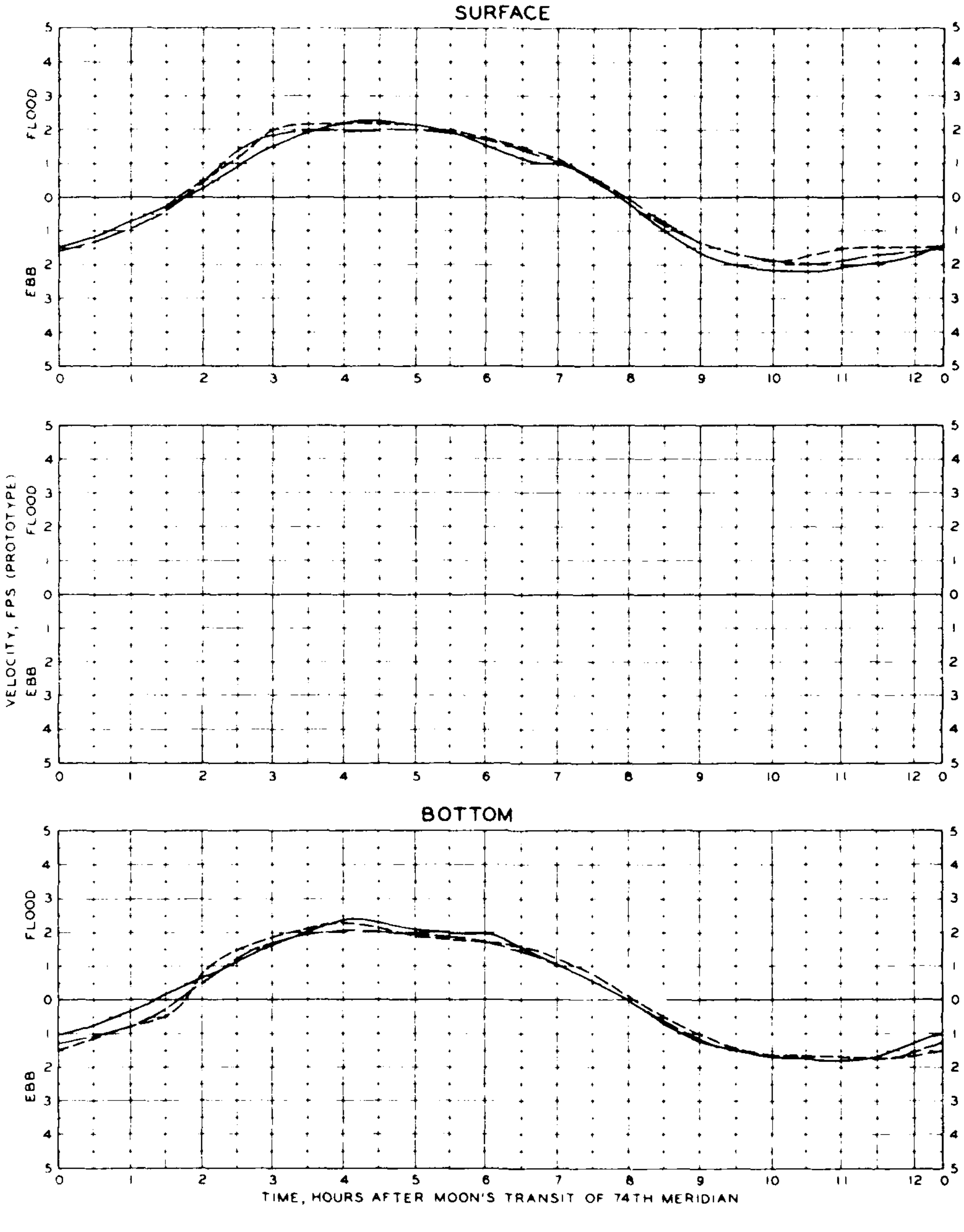
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 C.F.S. (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— BASE TEST 1967
------ PLAN 3
— — — PLAN 6

VELOCITY OBSERVATIONS

PLANS 3 AND 6
STATION 1 OC



MODEL TEST DATA

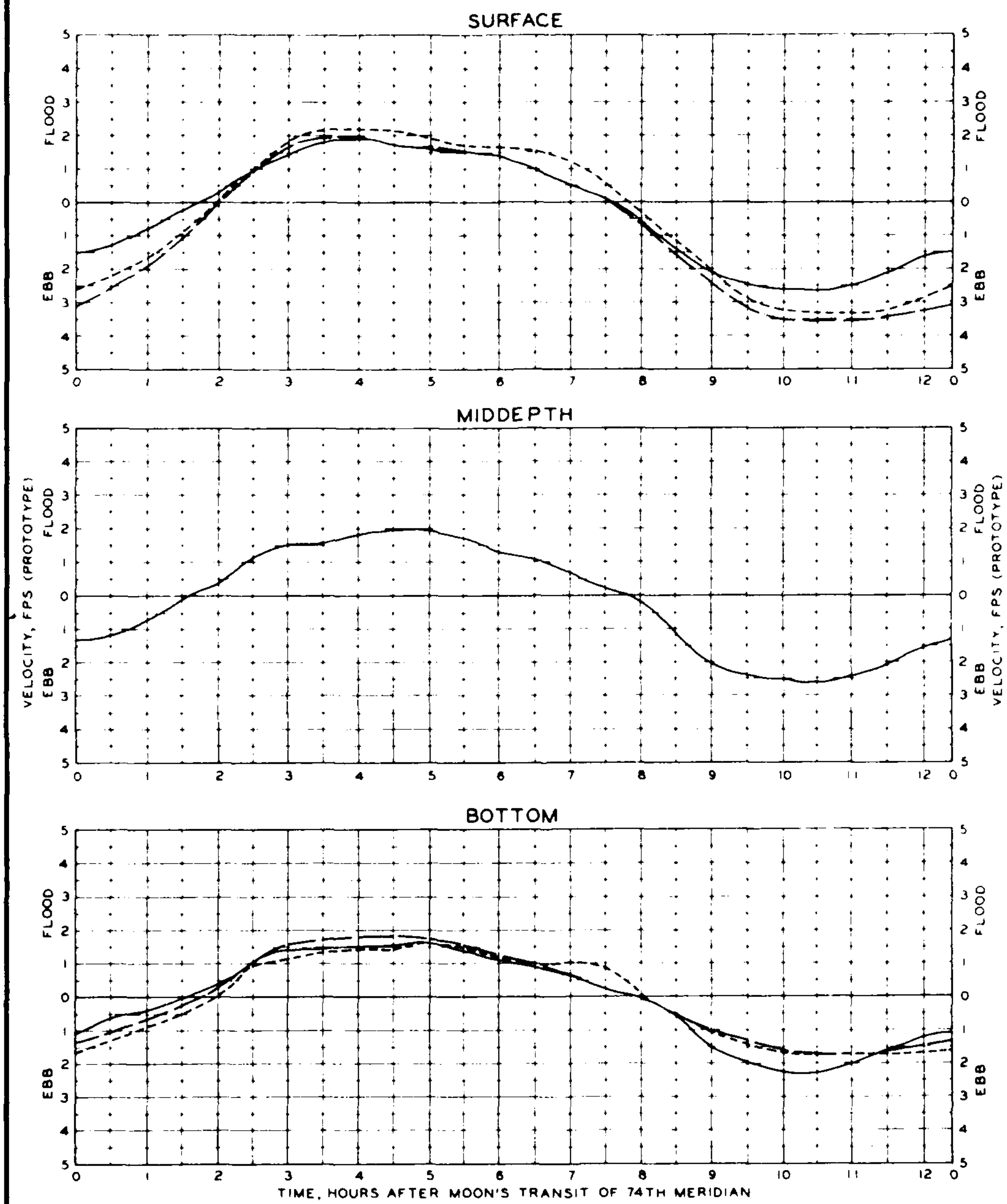
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 C F S (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

- ——— BASE TEST 1967
- - - - - - PLAN 3
- — — — PLAN 6

VELOCITY OBSERVATIONS

PLANS 3 AND 6
STATION 3 OC



MODEL TEST DATA

TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

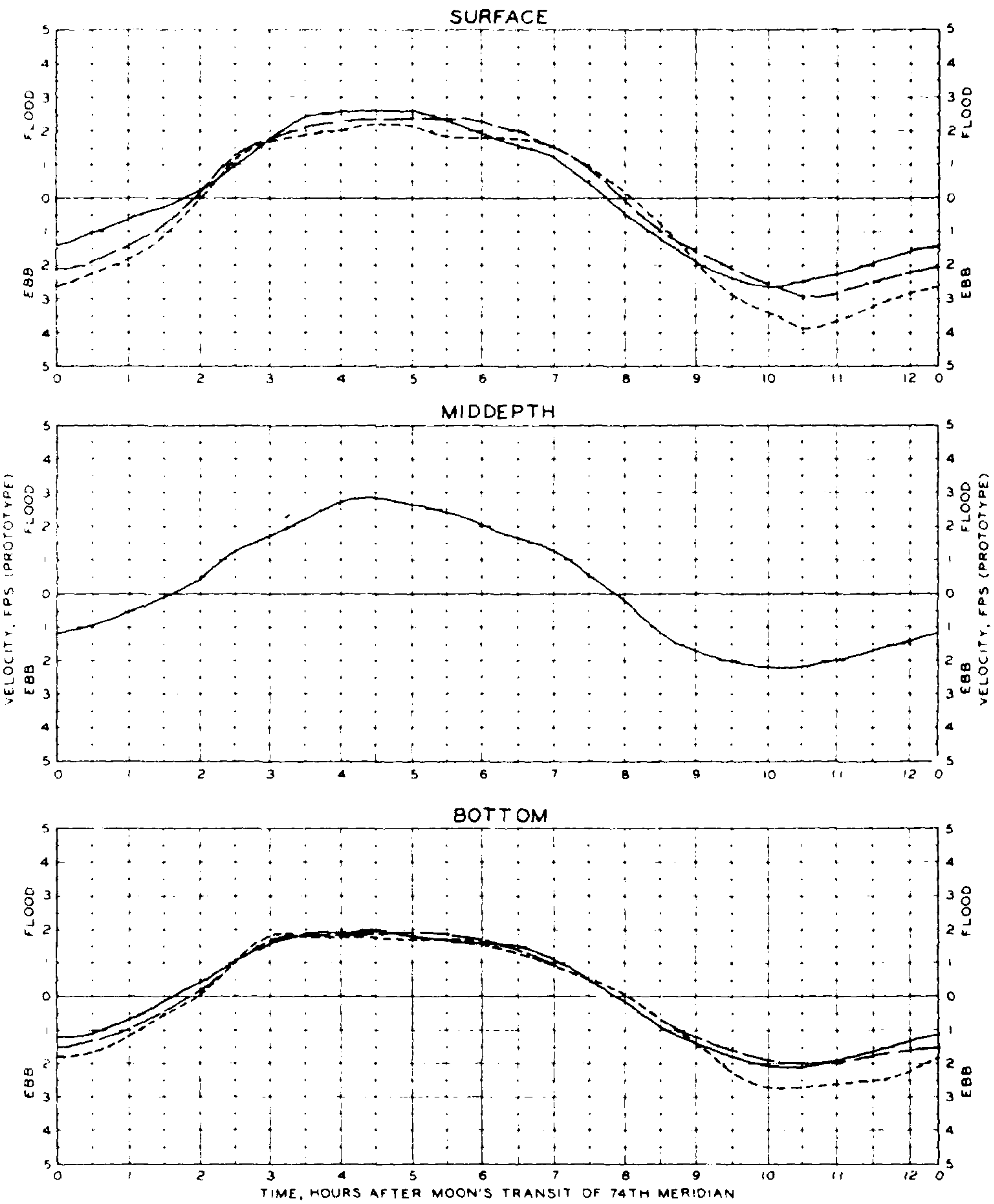
LEGEND

——— BASE TEST 1967
- - - - PLAN 3
— — — PLAN 6

VELOCITY OBSERVATIONS

PLANS 3 AND 6

STATION I V



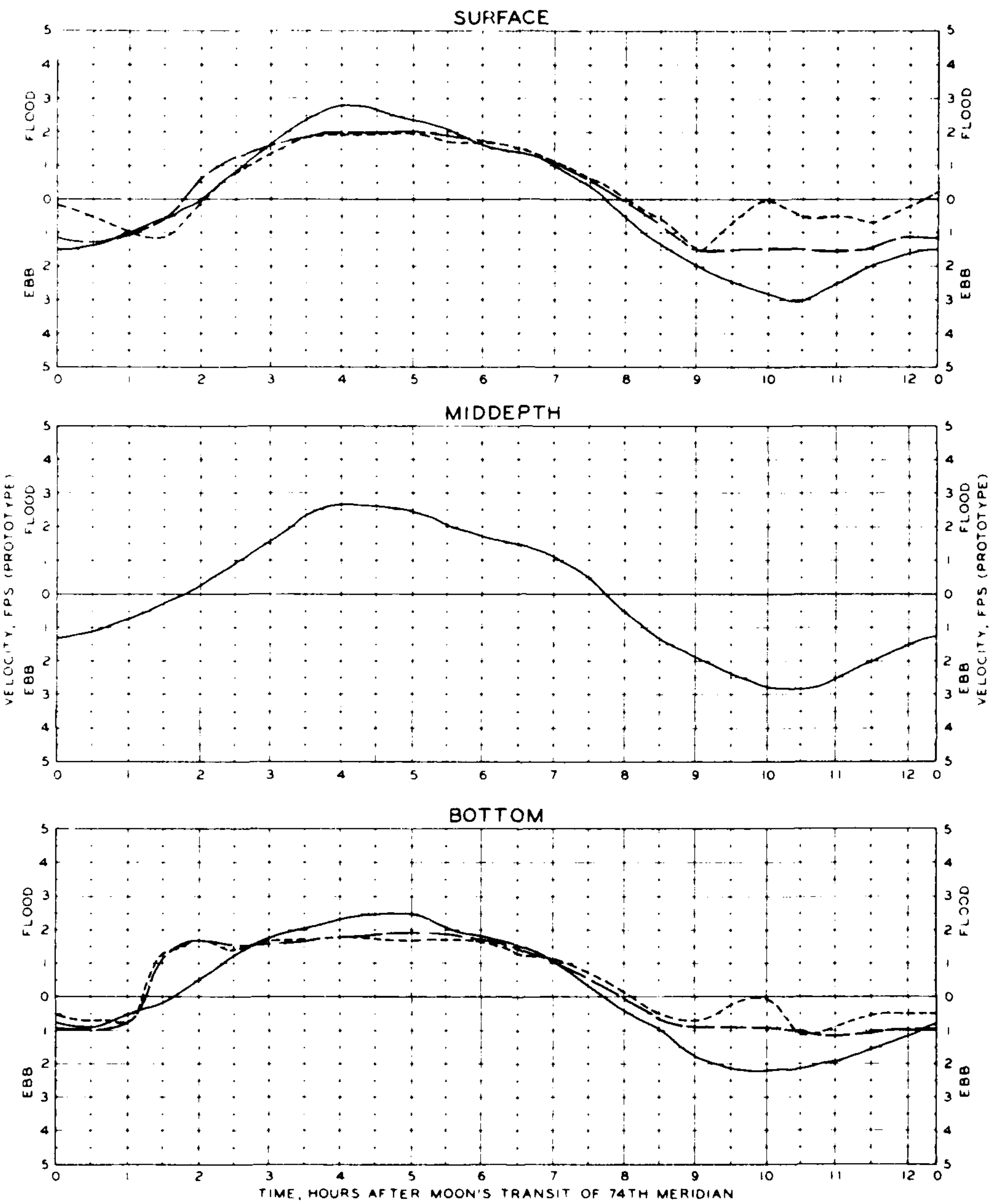
MODEL TEST DATA

TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— BASE TEST 1967
------ PLAN 3
— — — PLAN 6

VELOCITY OBSERVATIONS
PLANS 3 AND 6
STATION 2 V



MODEL TEST DATA

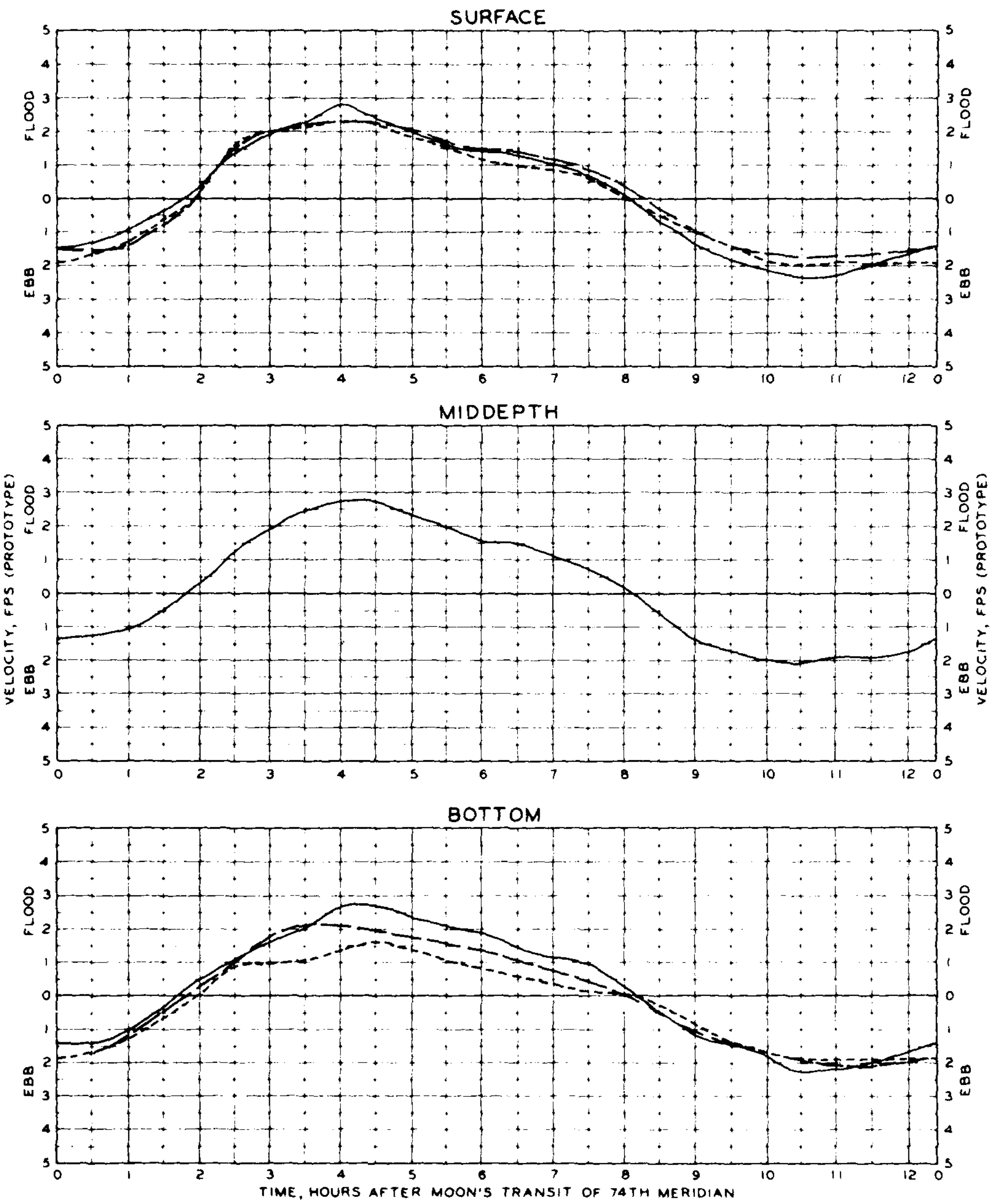
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

———— BASE TEST 1967
- - - - - - PLAN 3
— — — PLAN 6

VELOCITY OBSERVATIONS

PLANS 3 AND 6
STATION 3 V



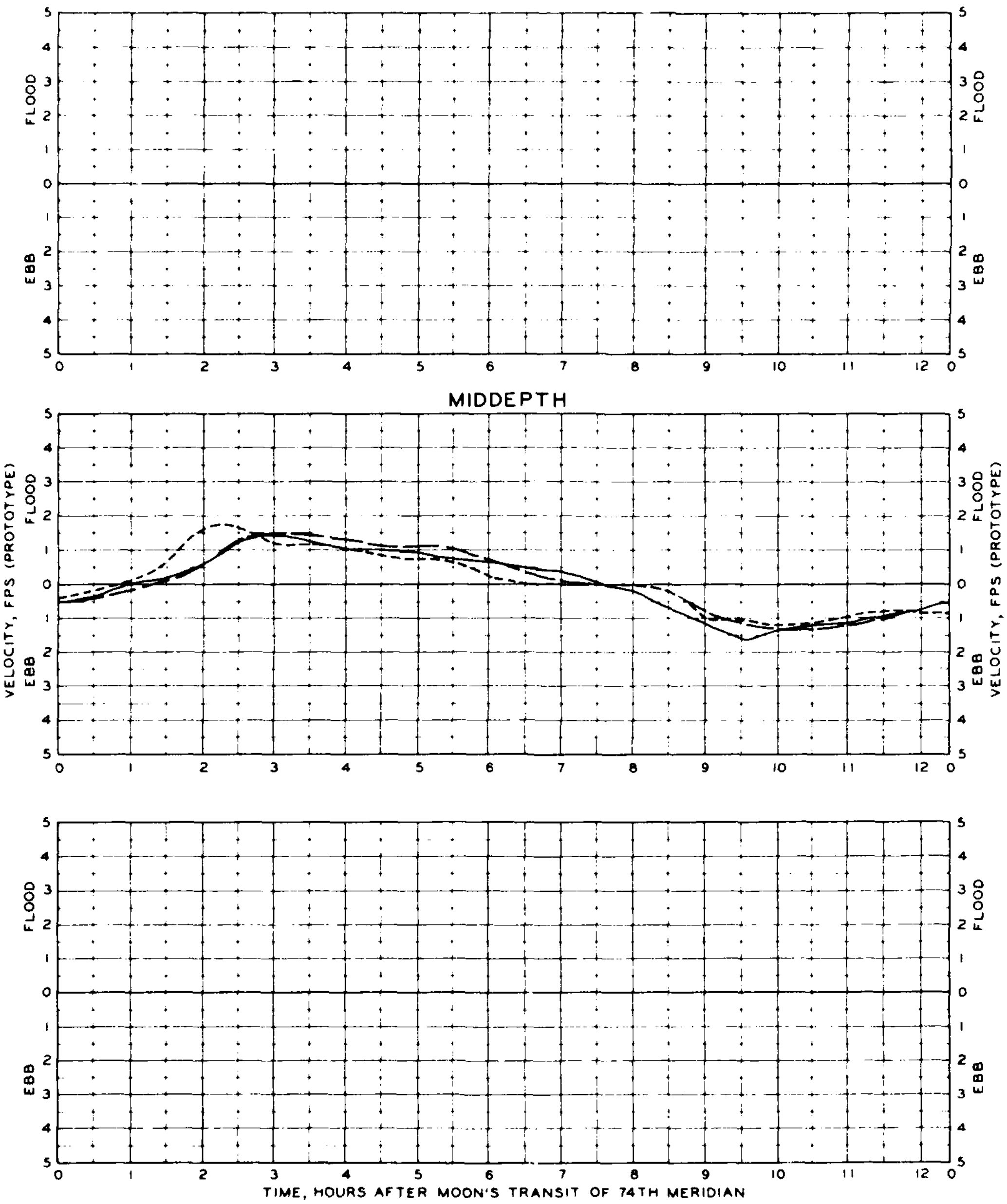
MODEL TEST DATA

TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— BASE TEST 1967
- - - - PLAN 3
— — — PLAN 6

VELOCITY OBSERVATIONS
PLANS 3 AND 6
STATION 4 V



MODEL TEST DATA

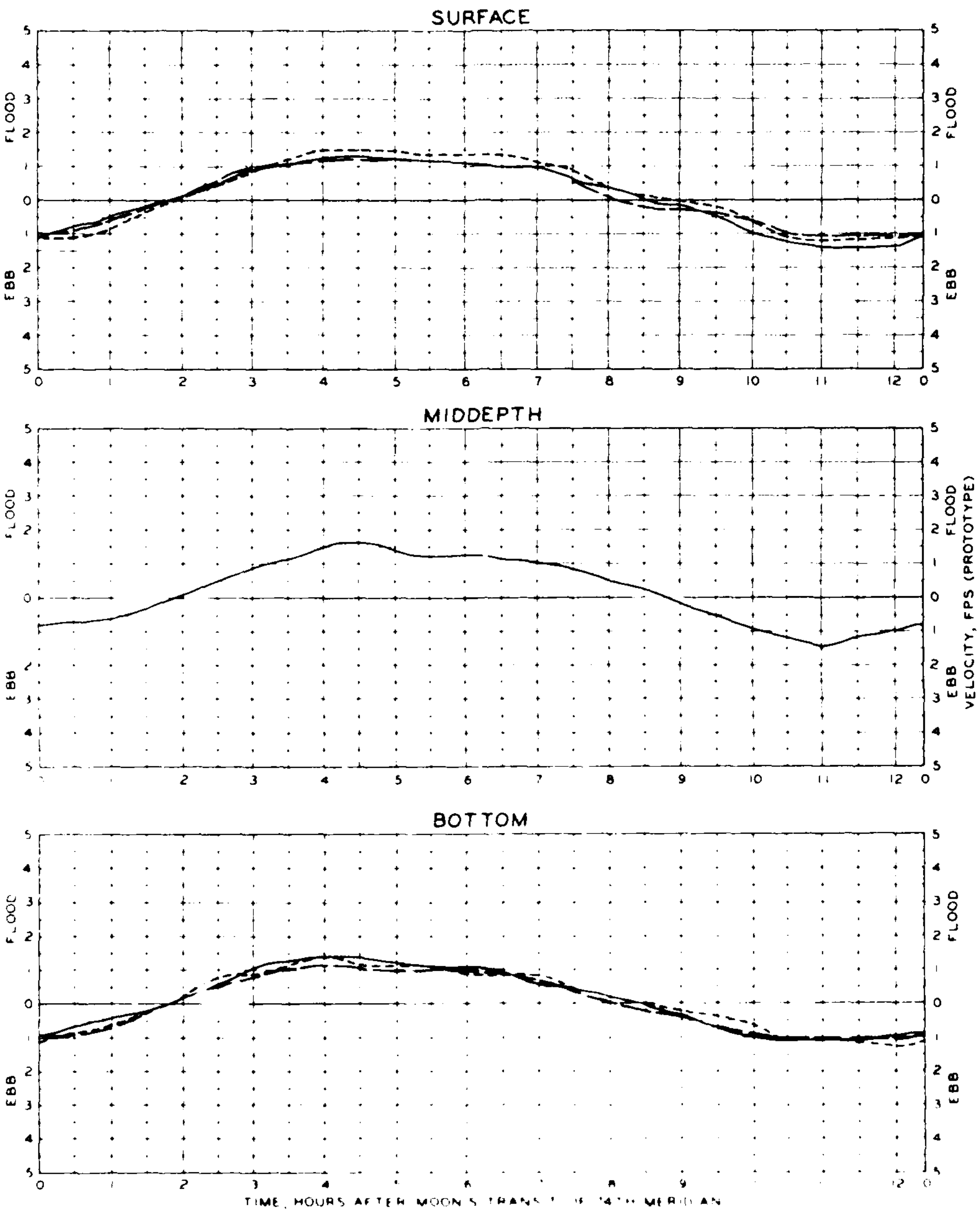
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

- ——— BASE TEST 1967
- - - - - - PLAN 3
- — — — PLAN 6

VELOCITY OBSERVATIONS

PLANS 3 AND 6
STATION 5 V



MODEL TEST DATA

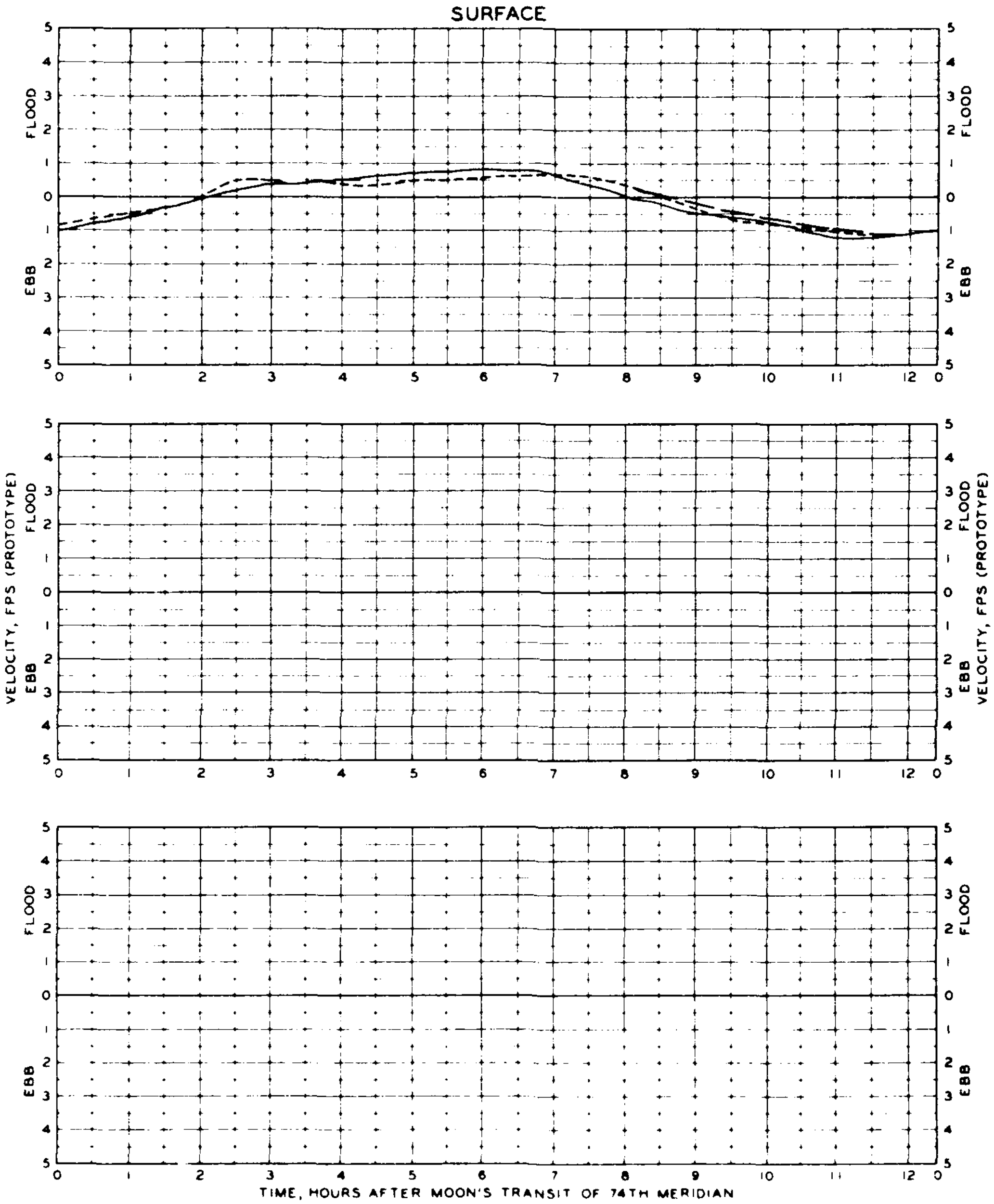
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— BASE TEST 1967
------ PLAN 3
— — — PLAN 6

VELOCITY OBSERVATIONS

PLANS 3 AND 6
STATION 6 V



MODEL TEST DATA

TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

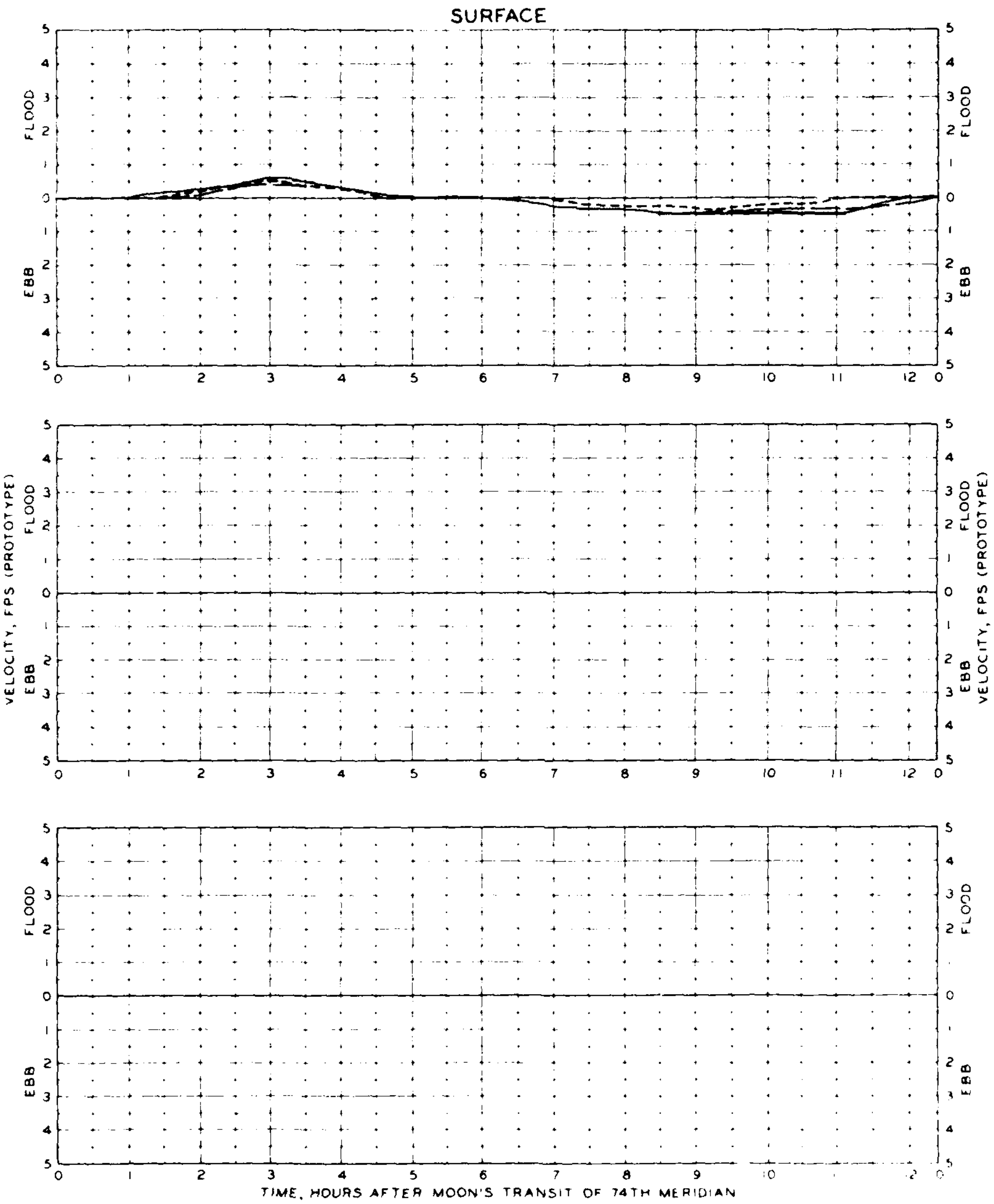
LEGEND

——— BASE TEST 1967
------ PLAN 3
— — — PLAN 6

VELOCITY OBSERVATIONS

PLANS 3 AND 6

STATION 7 V



MODEL TEST DATA

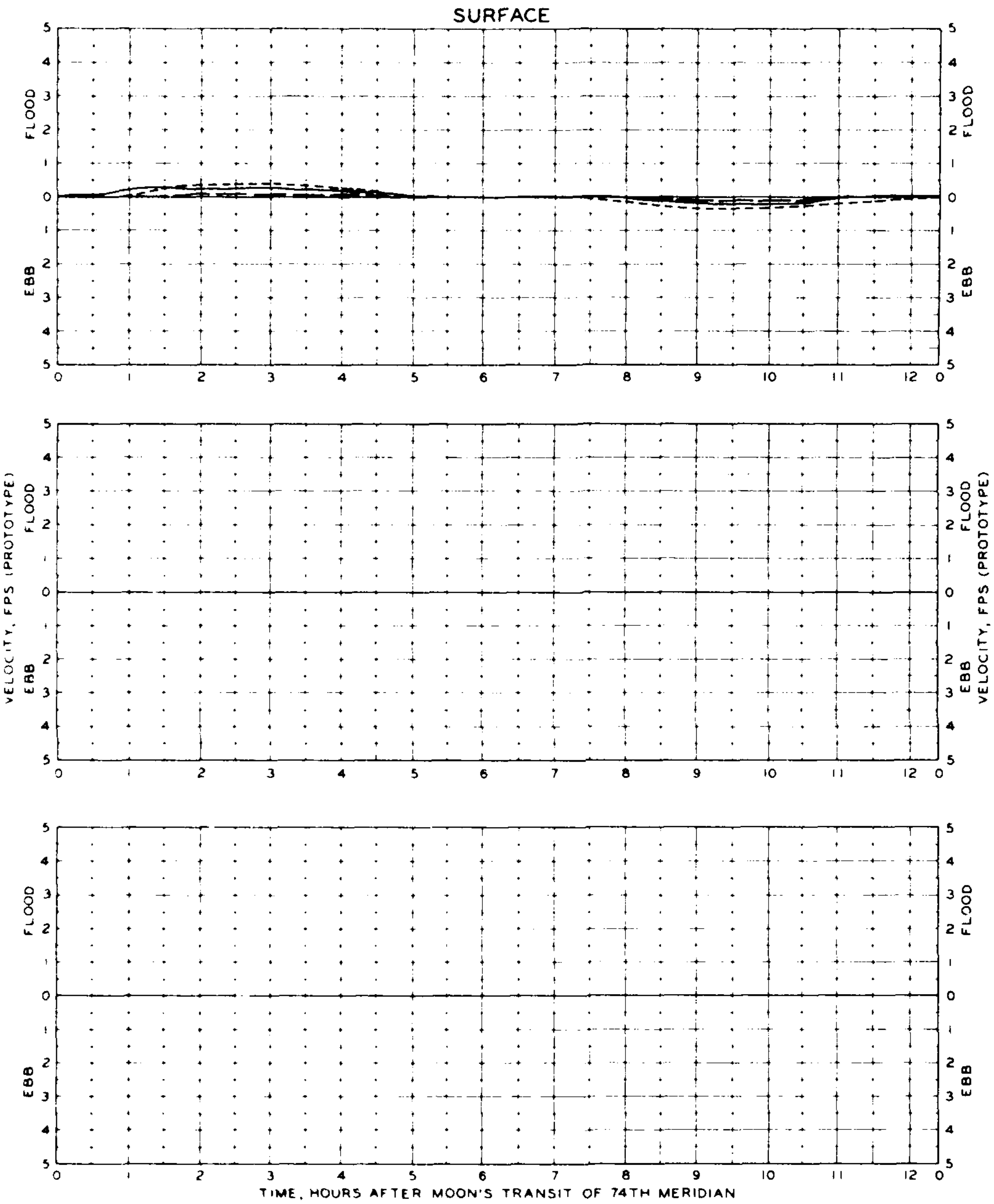
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— BASE TEST 1967
------ PLAN 3
— — — PLAN 6

VELOCITY OBSERVATIONS

PLANS 3 AND 6
STATION 8 V



MODEL TEST DATA

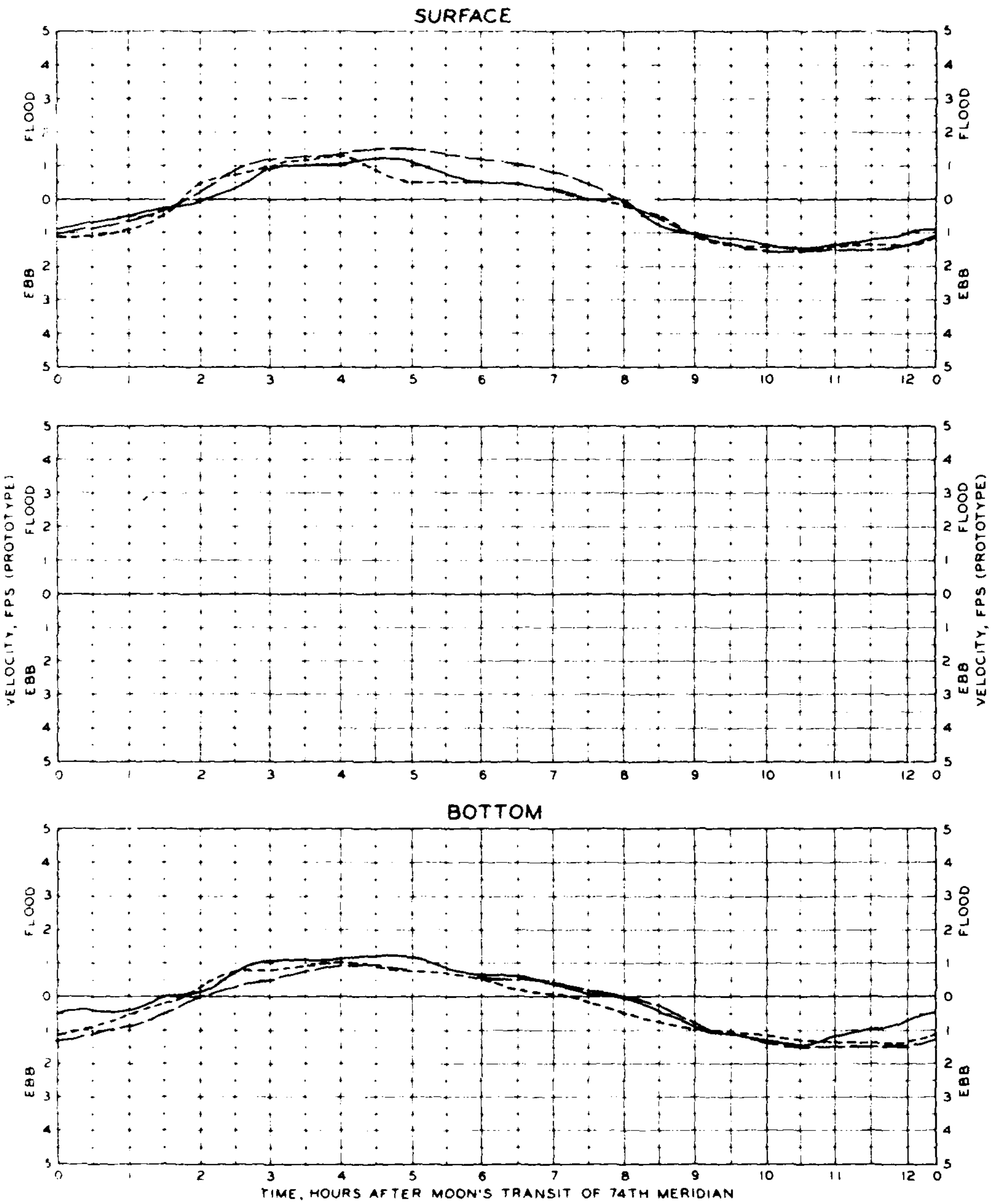
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— BASE TEST 1967
------ PLAN 3
— — — PLAN 6

VELOCITY OBSERVATIONS

PLANS 3 AND 6
STATION 9 V



MODEL TEST DATA

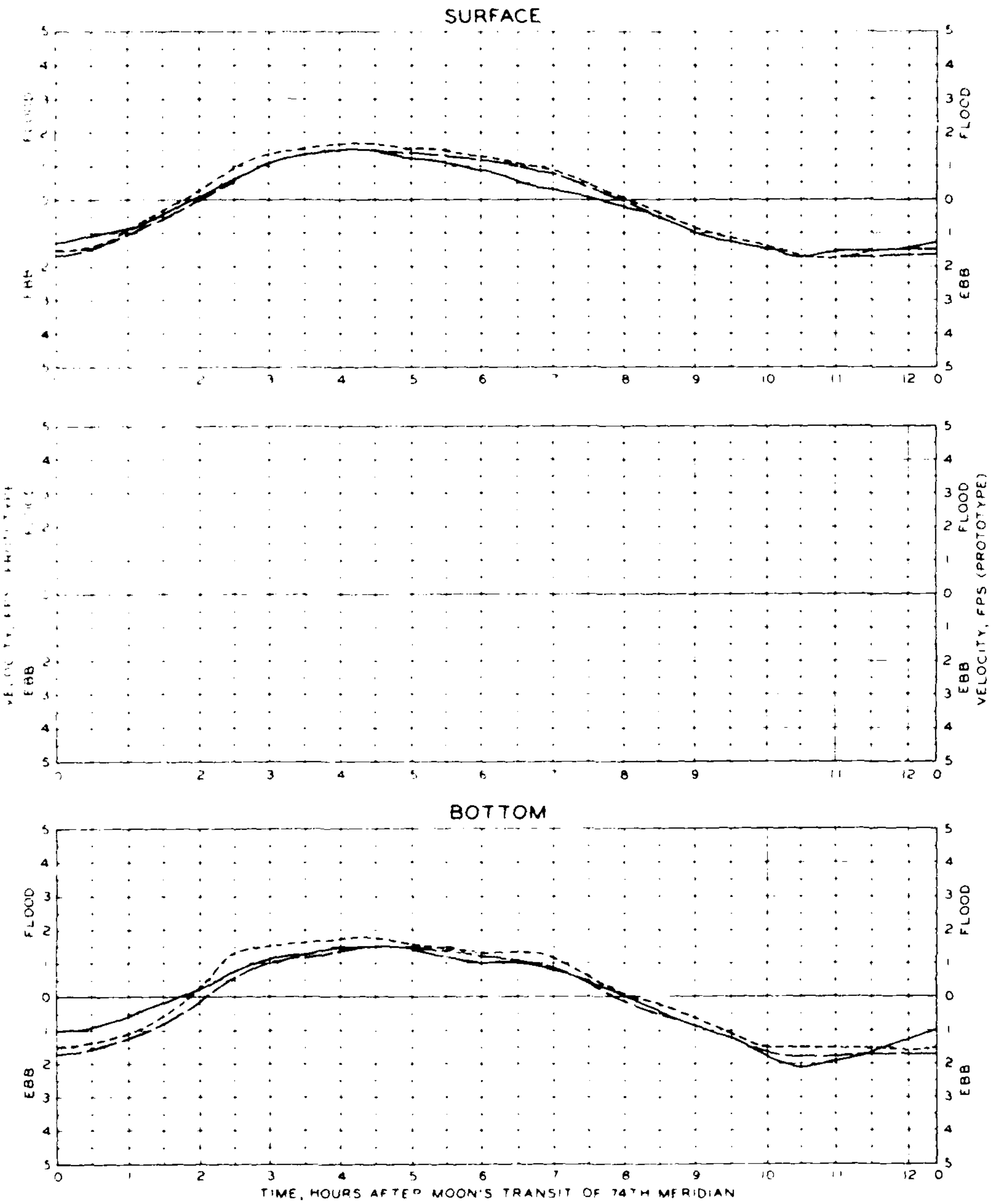
TIDE MEAN
FRESHWATER DISCHARGE 12,000 CFS (MEAN)
OCEAN SALINITY 30,000 PPM

LEGEND

—— BASE TEST 1967
- - - - PLAN 3
— — PLAN 6

VELOCITY OBSERVATIONS

PLANS 3 AND 6
STATION O BCH



MODEL TEST DATA

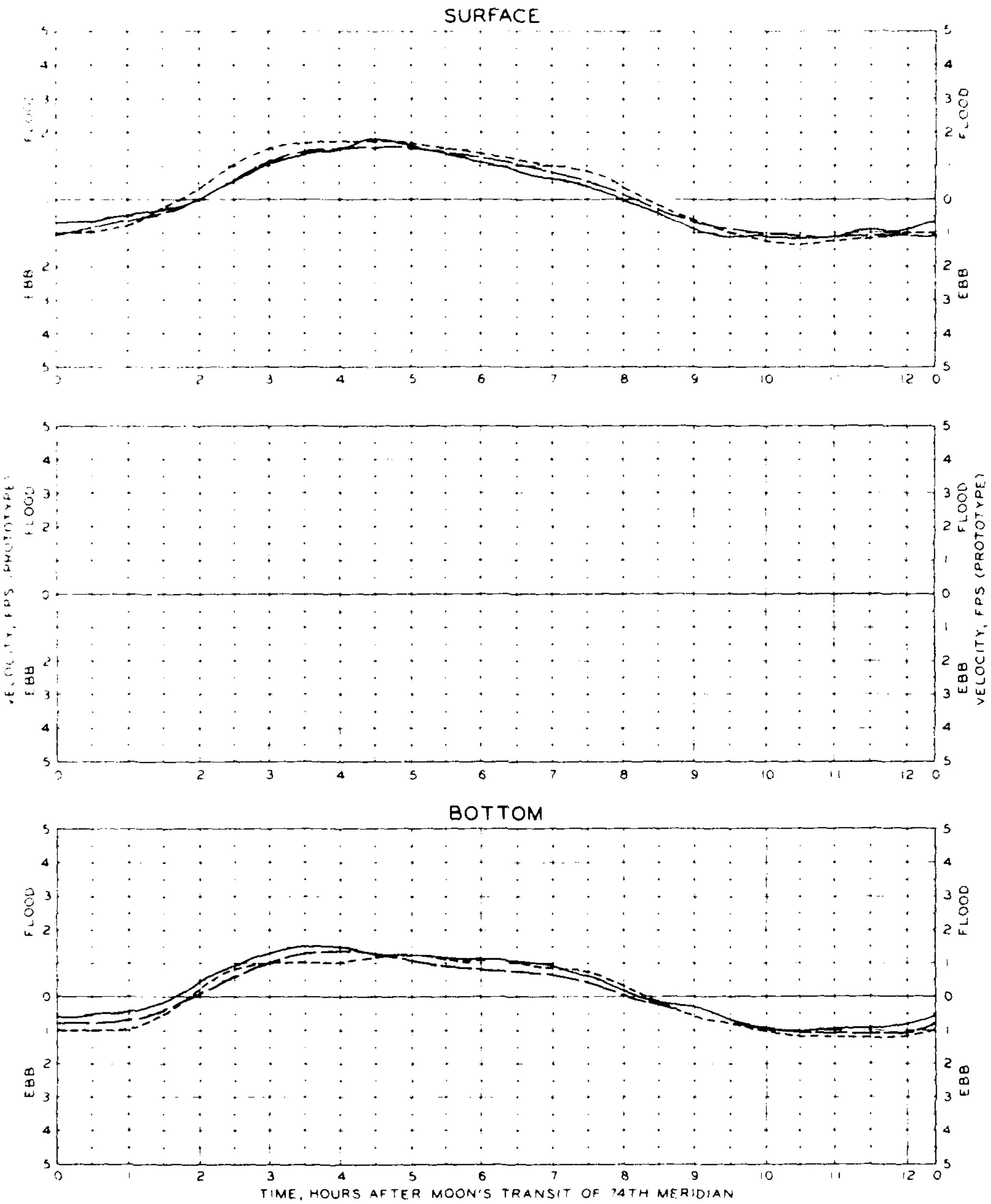
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— BASE TEST 1967
- - - - - PLAN 3
— — — PLAN 6

VELOCITY OBSERVATIONS

PLANS 3 AND 6
STATION 1 BCH



MODEL TEST DATA

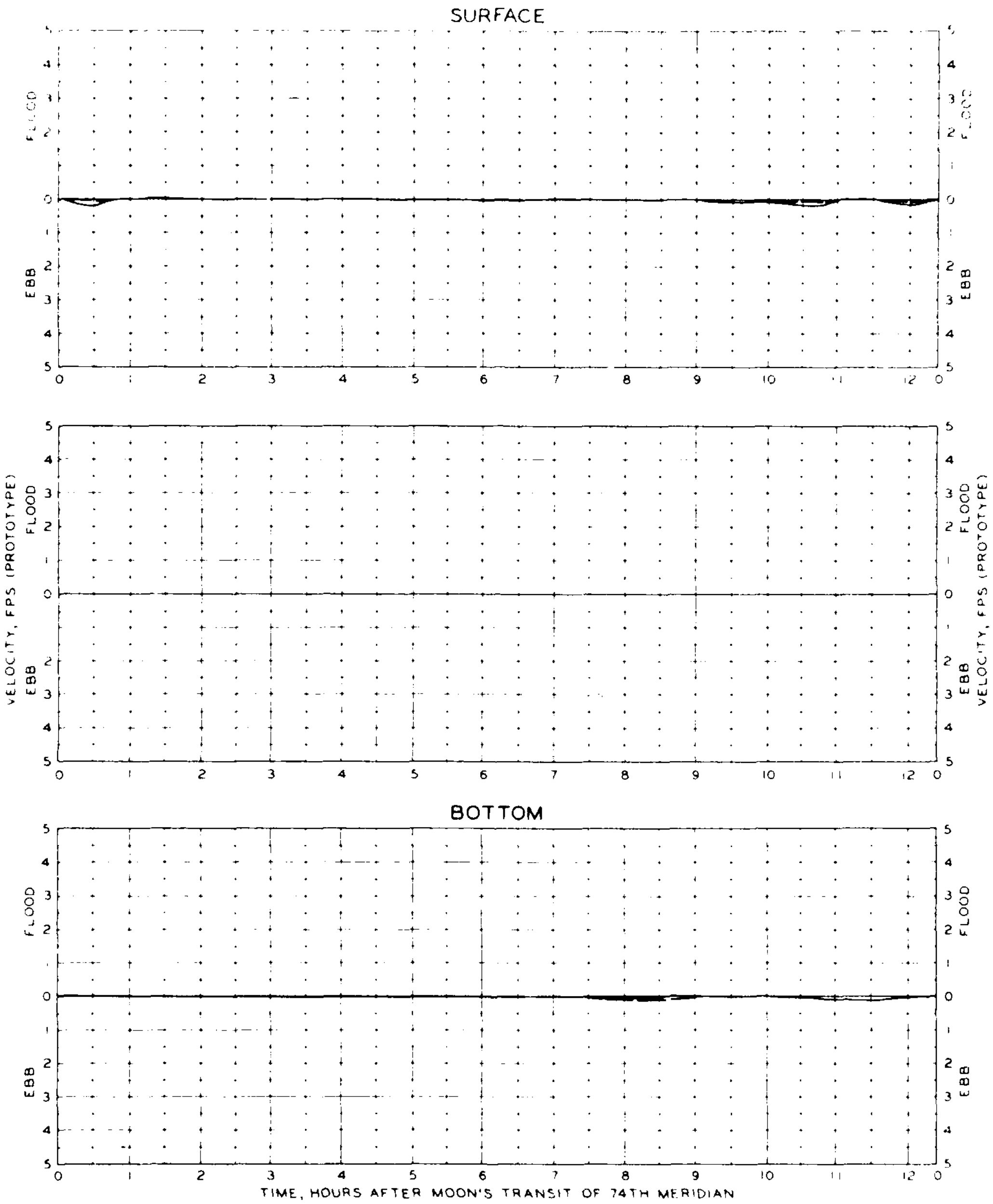
TIDE MEAN
FRESHWATER DISCHARGE 12,000 CFS (MEAN)
OCEAN SALINITY 30,000 PPM

LEGEND

BASE TEST 1967
PLAN 3
PLAN 6

VELOCITY OBSERVATIONS

PLANS 3 AND 6
STATION 4 BCH



MODEL TEST DATA

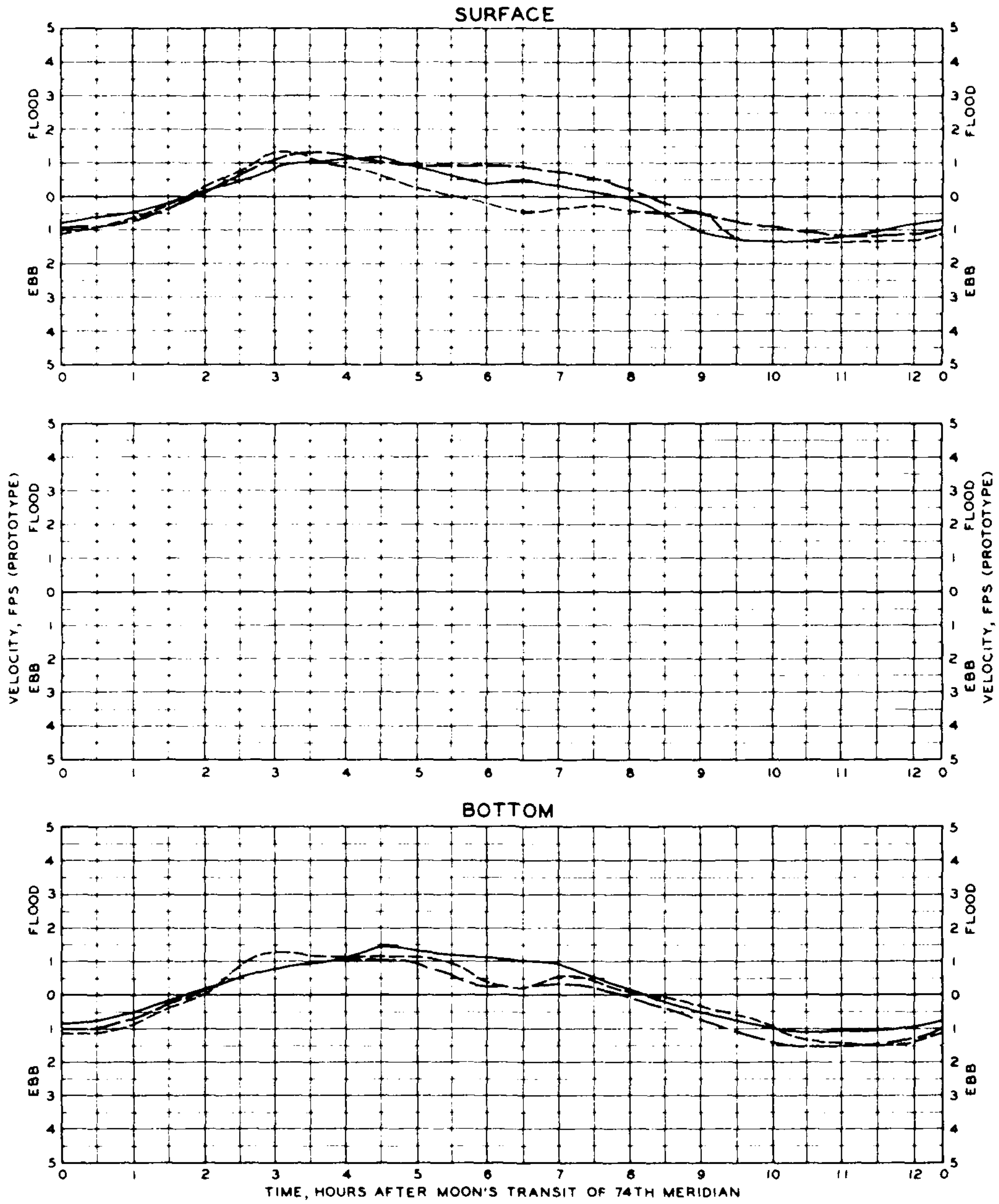
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— BASE TEST 1967
------ PLAN 3
— — — PLAN 6

VELOCITY OBSERVATIONS

PLANS 3 AND 6
STATION 8 BCH



MODEL TEST DATA

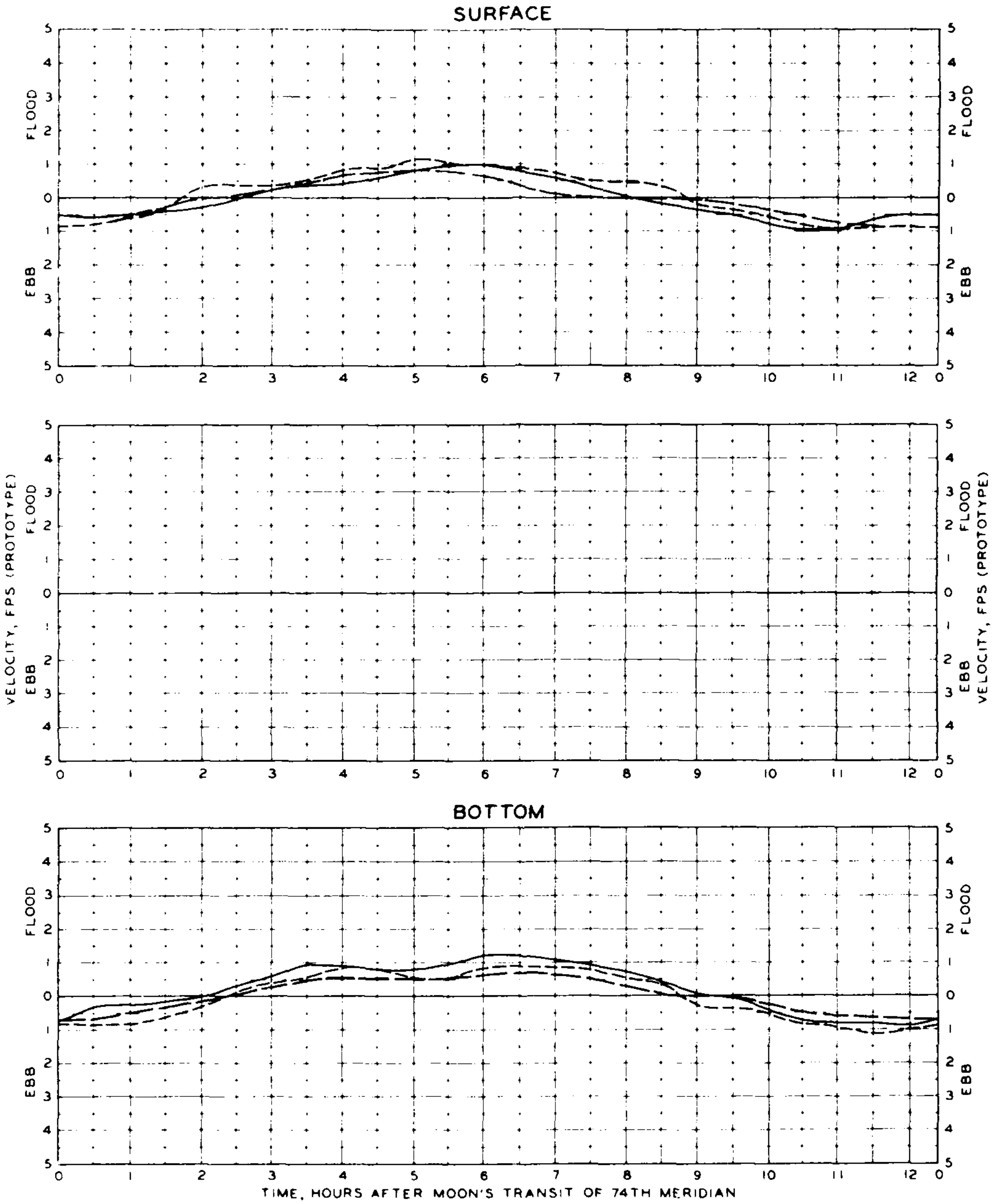
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— BASE TEST 1967
------ PLAN 3
-·-·— PLAN 6

VELOCITY OBSERVATIONS

PLANS 3 AND 6
STATION 7 ICH



MODEL TEST DATA

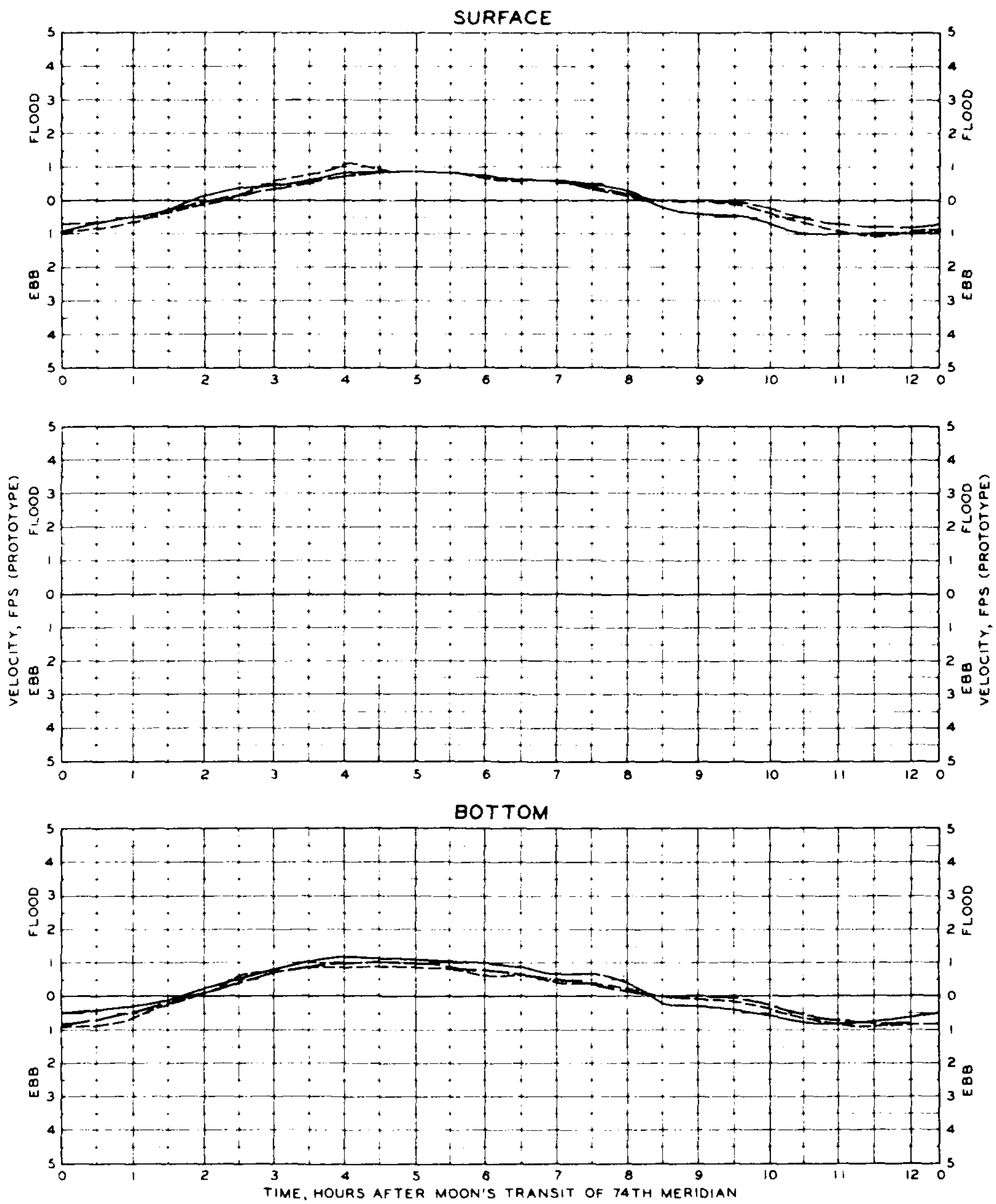
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— BASE TEST 1967
------ PLAN 3
— — — PLAN 6

VELOCITY OBSERVATIONS

PLANS 3 AND 6
STATION 9 ICH



MODEL TEST DATA

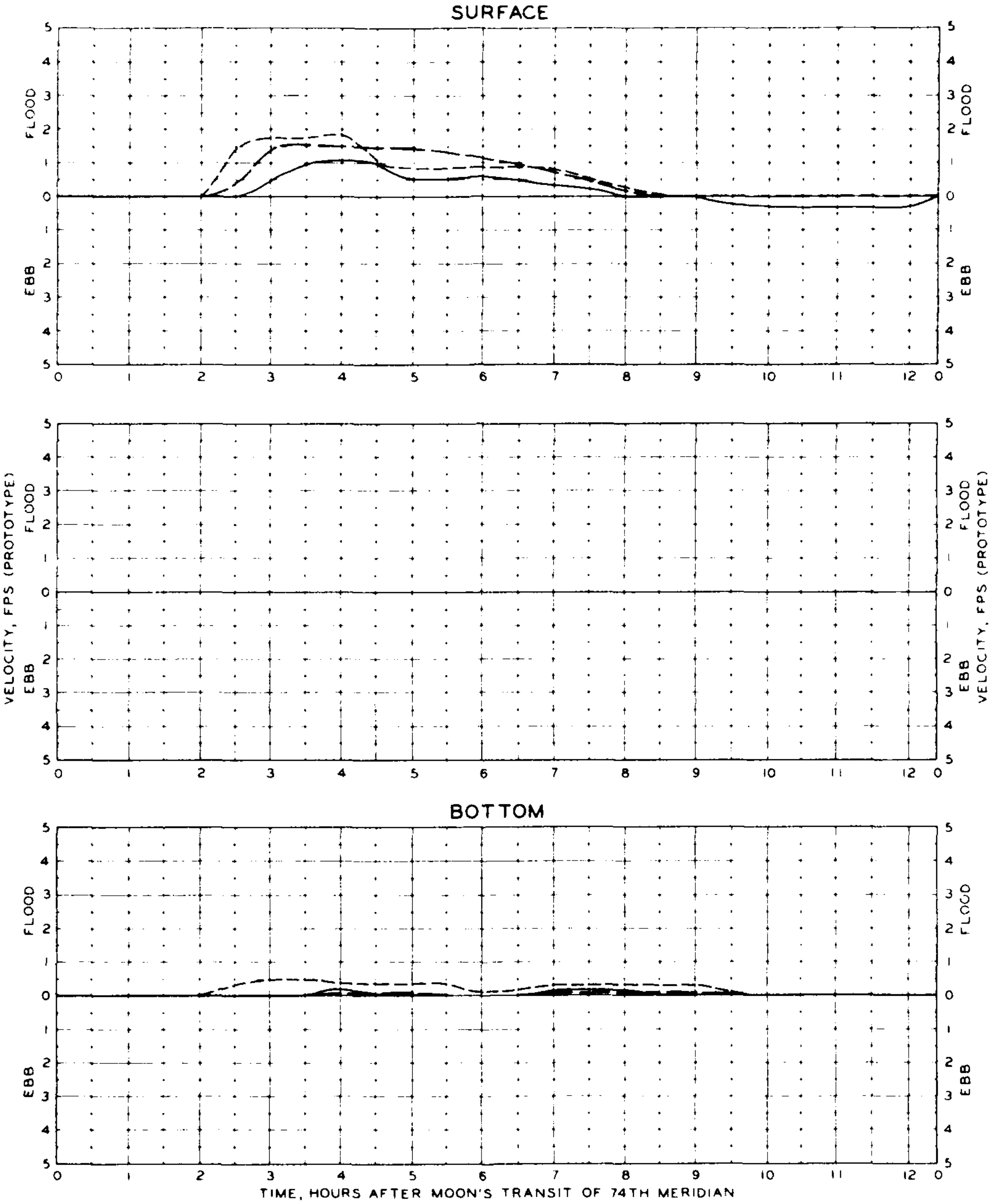
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— BASE TEST 1967
- - - - PLAN 3
— — — PLAN 6

VELOCITY OBSERVATIONS

PLANS 3 AND 6
STATION 11 ICH



MODEL TEST DATA

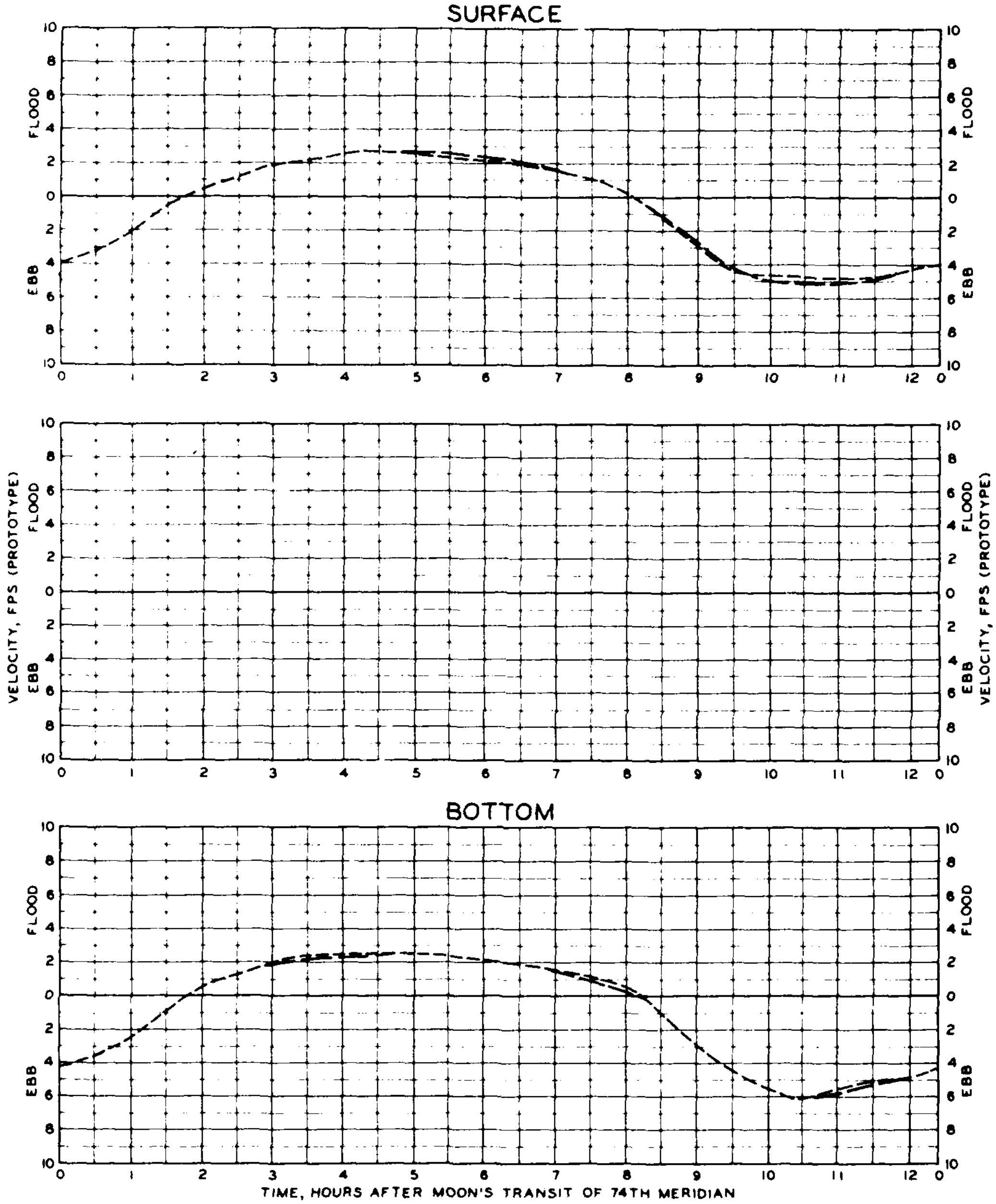
TIDE	MEAN
FRESHWATER DISCHARGE	2,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— BASE TEST 1967
------ PLAN 3
— — — PLAN 6

VELOCITY OBSERVATIONS

PLANS 3 AND 6
STATION 13 ICH



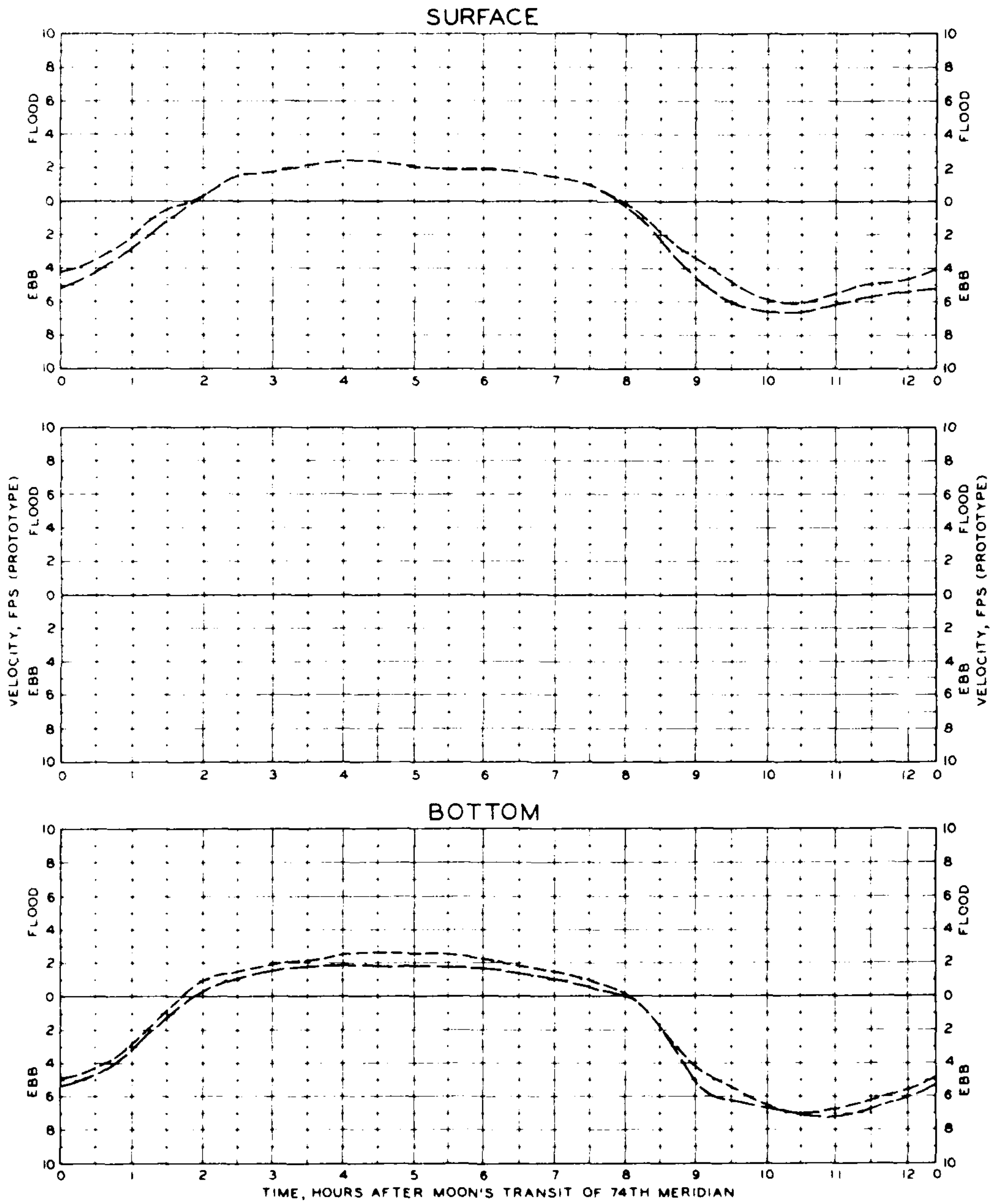
MODEL TEST DATA

TIDE . . . . MEAN
FRESHWATER DISCHARGE 12,000 CFS (MEAN)
OCEAN SALINITY . . . . 30,000 PPM

LEGEND

------ PLAN 3
— — — PLAN 6

VELOCITY OBSERVATIONS
PLANS 3 AND 6
STATION 14 V



MODEL TEST DATA

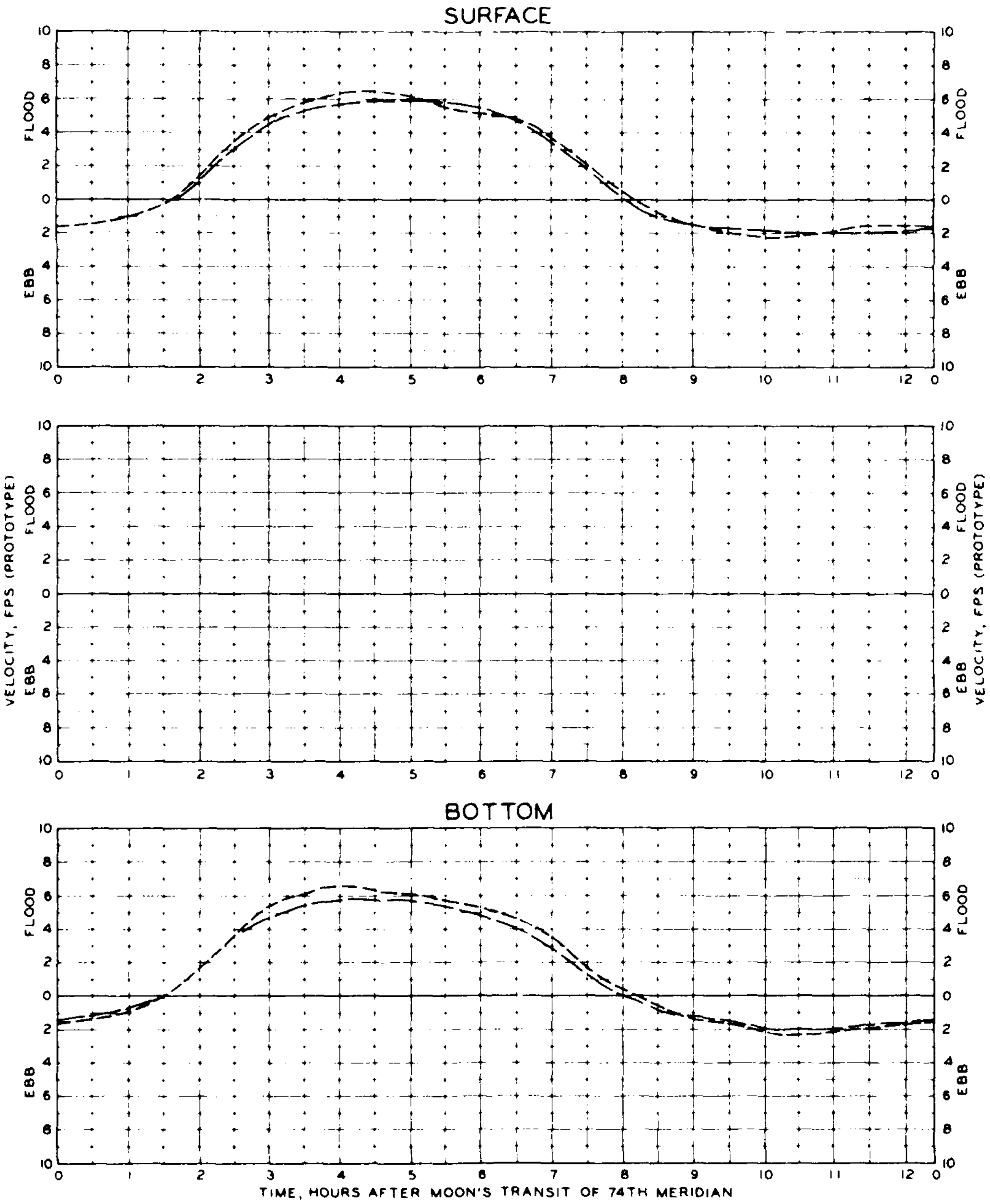
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

- – – – – PLAN 3
- —— —— PLAN 6

VELOCITY OBSERVATIONS

PLANS 3 AND 6
STATION 15 V



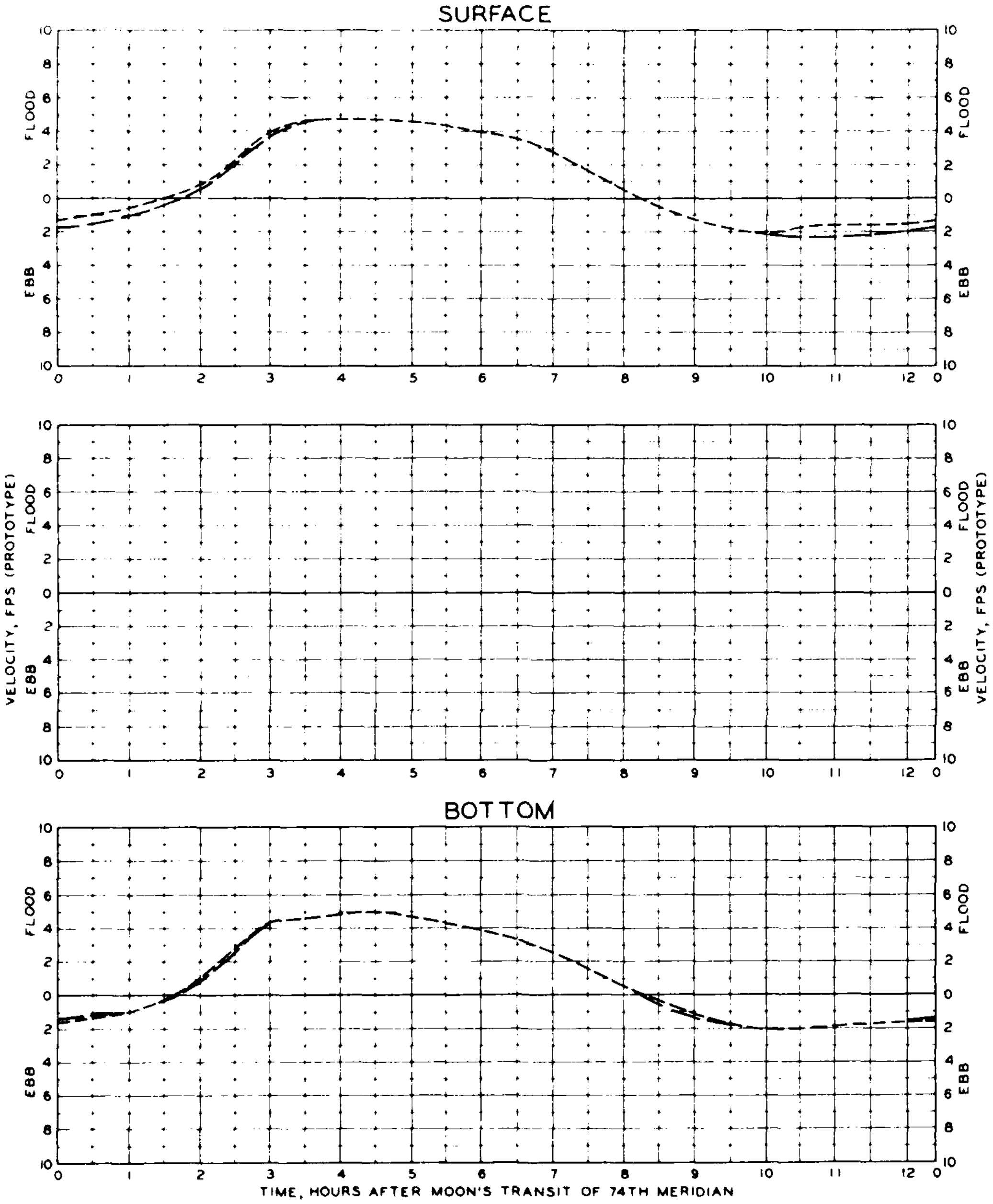
MODEL TEST DATA

TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

- - - - - PLAN 3
— — — PLAN 6

VELOCITY OBSERVATIONS
PLANS 3 AND 6
STATION 16 V



MODEL TEST DATA

TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

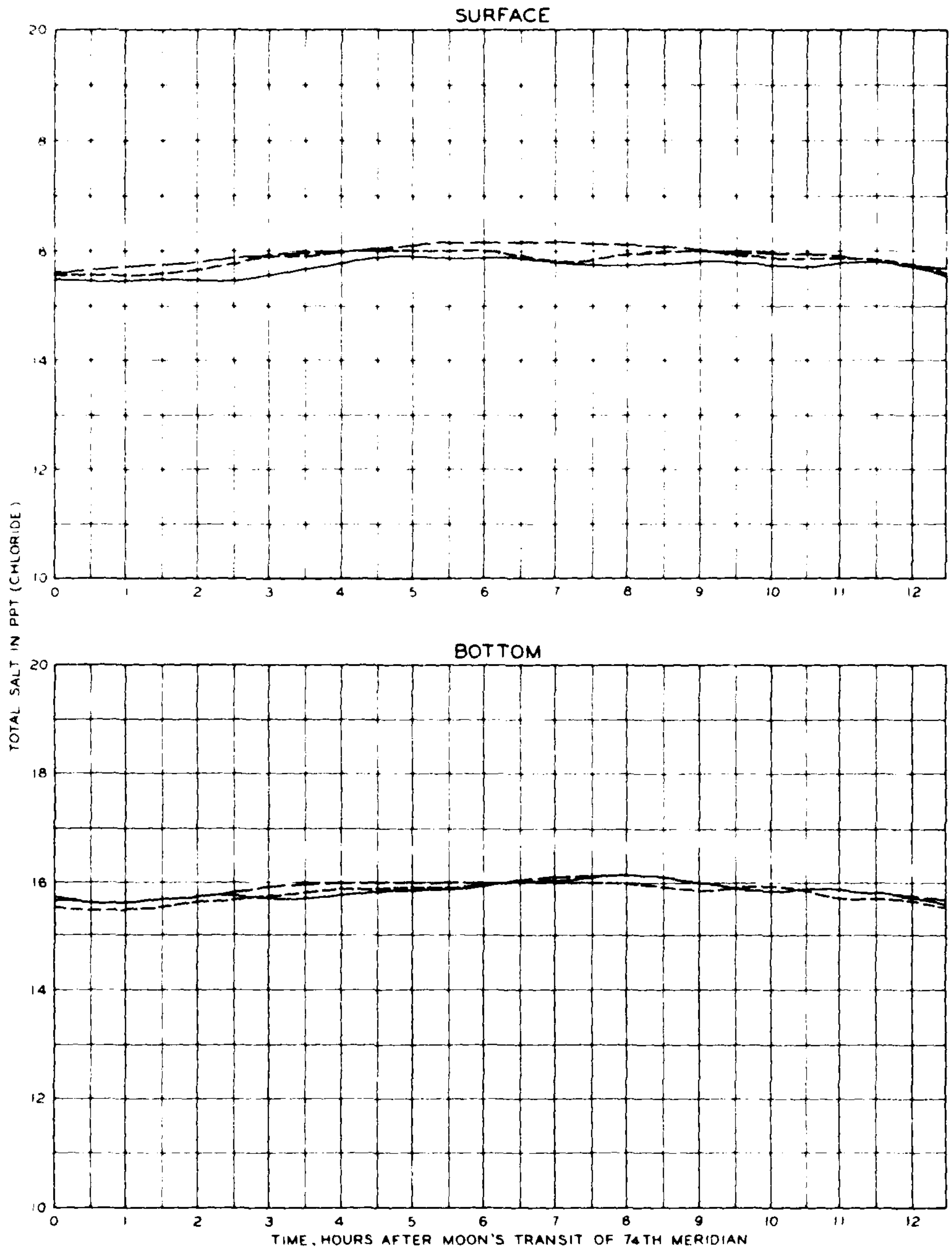
LEGEND

------ PLAN 3
— — — PLAN 6

VELOCITY OBSERVATIONS

PLANS 3 AND 6

STATION 17 V



MODEL TEST DATA

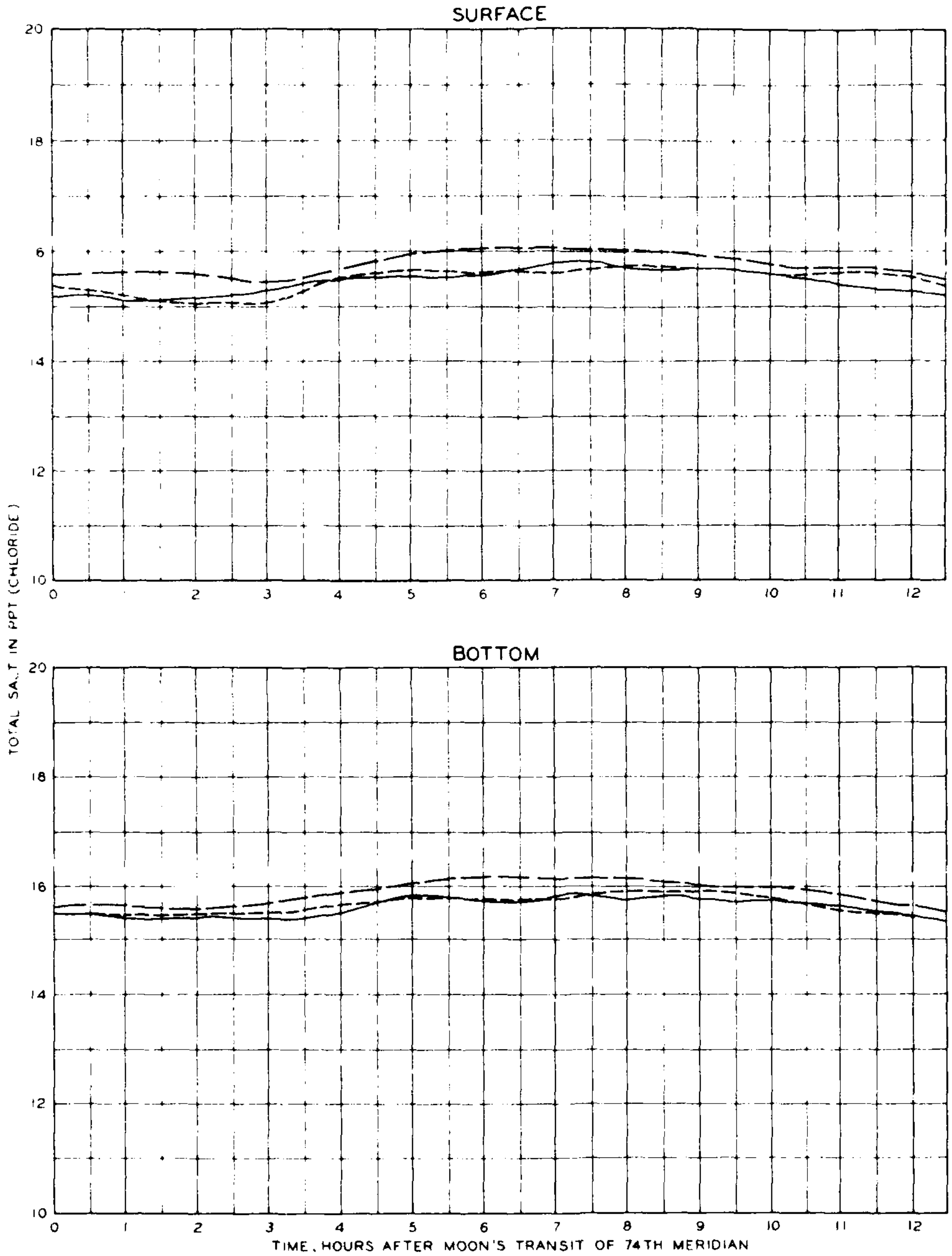
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

- ——— BASE TEST 1967
- - - - - - PLAN 3
- — - — PLAN 6

SALINITY DISTRIBUTION

PLANS 3 AND 6
STATION 10C



MODEL TEST DATA

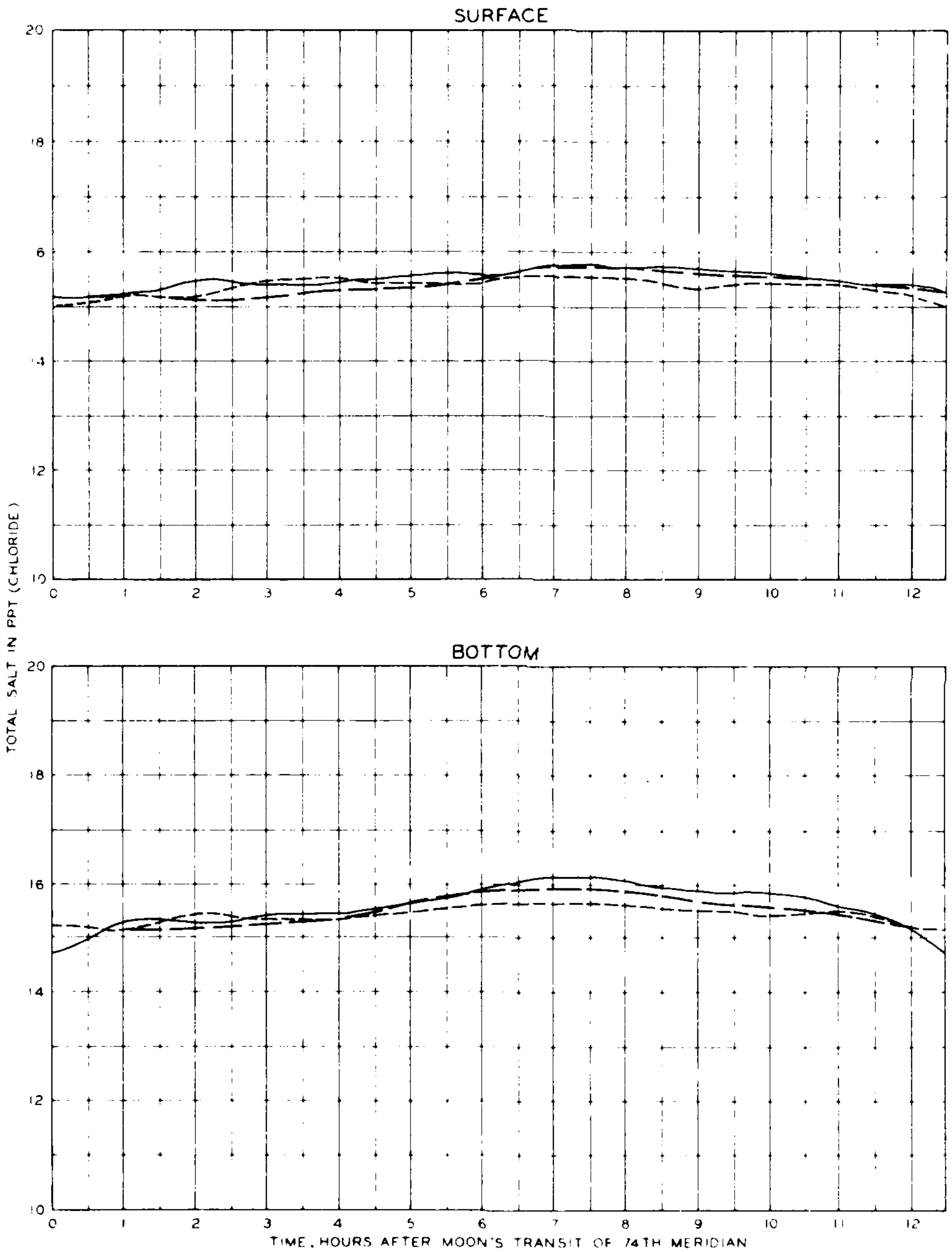
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

—— BASE TEST 1967
- - - PLAN 3
— — PLAN 6

SALINITY DISTRIBUTION

PLANS 3 AND 6
STATION 3 OC



MODEL TEST DATA

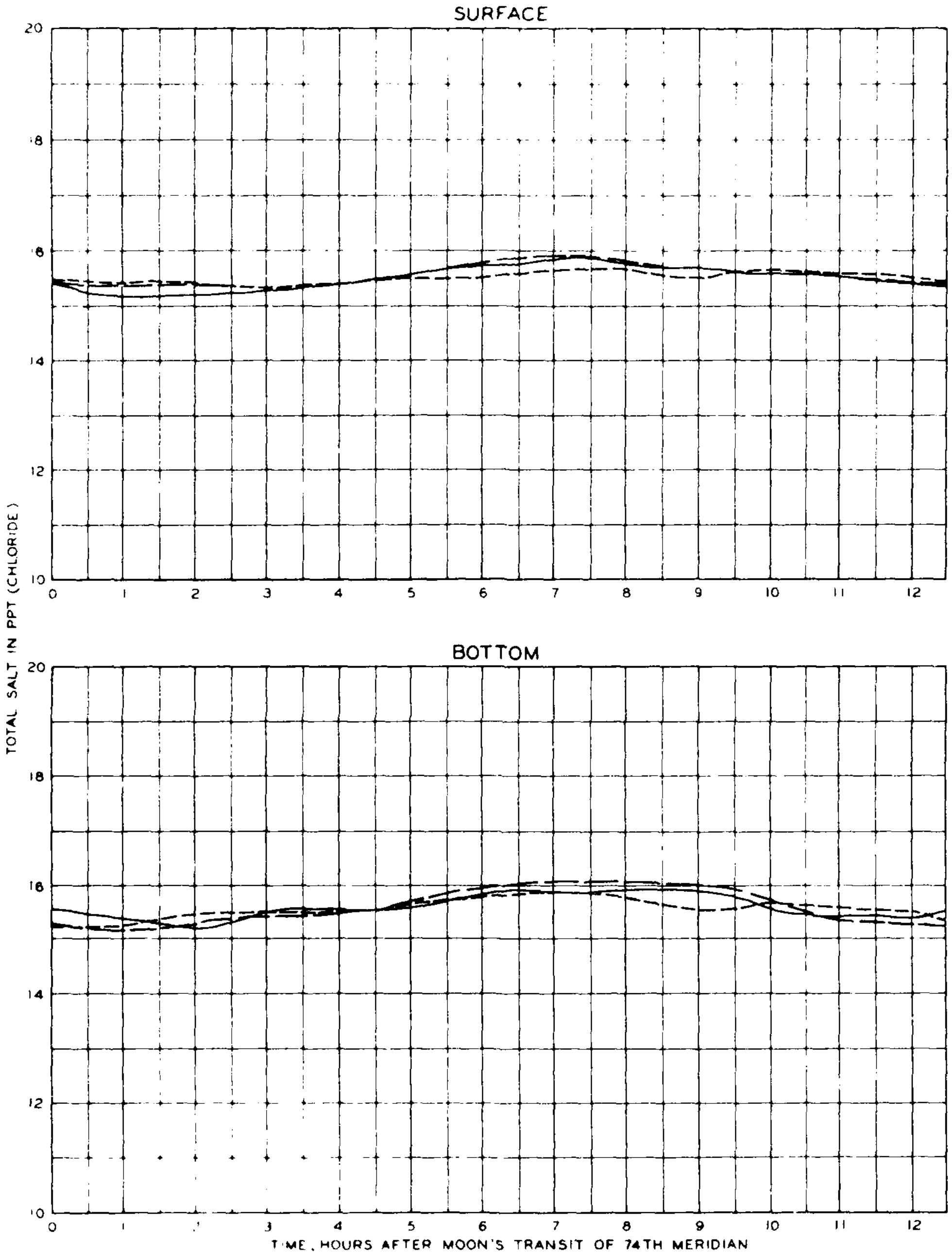
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— BASE TEST 1967
------ PLAN 3
— — — PLAN 6

SALINITY DISTRIBUTION

PLANS 3 AND 6
STATION IV



MODEL TEST DATA

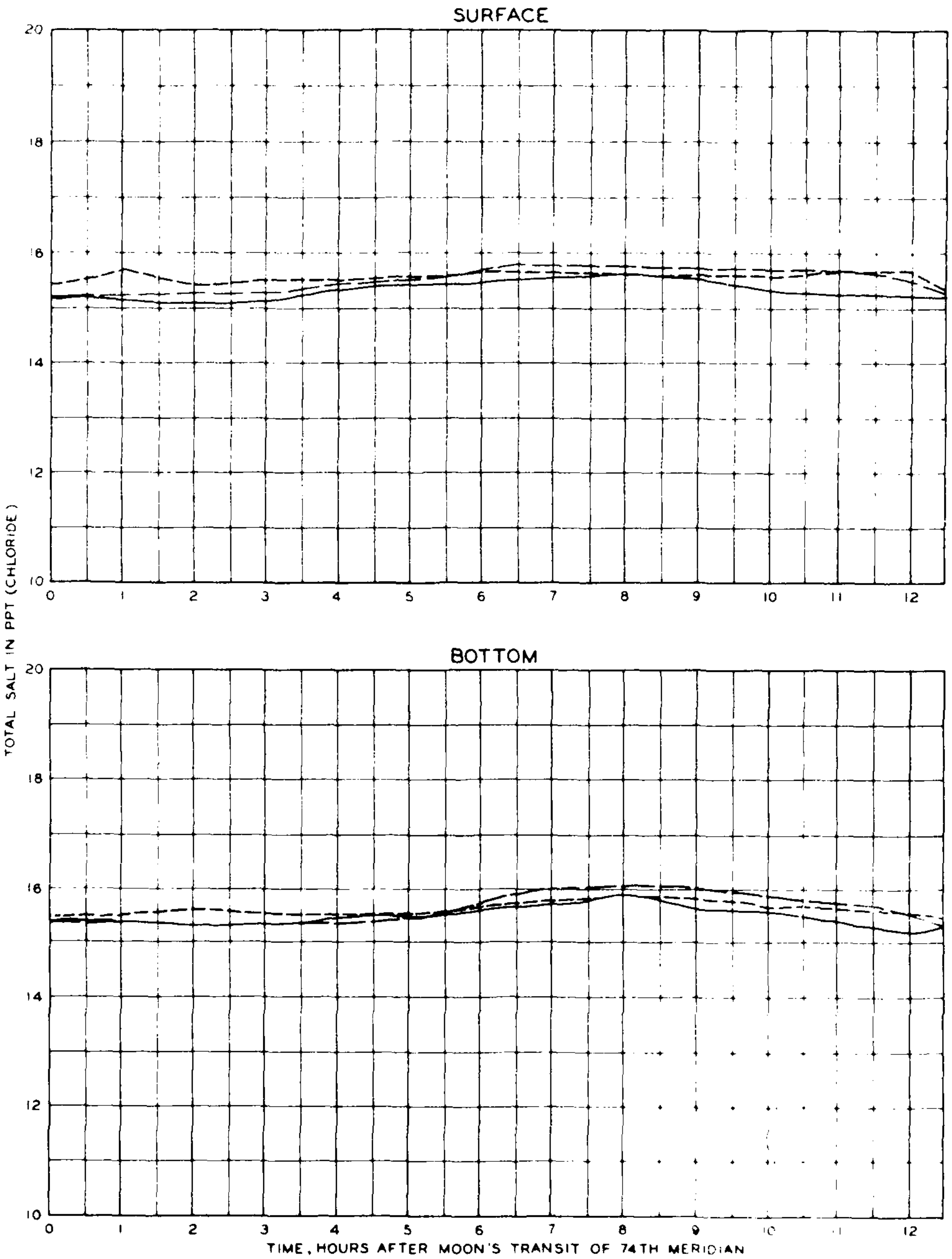
TIDE MEAN
FRESHWATER DISCHARGE 12,000 CFS (MEAN)
OCEAN SALINITY 30,000 PPM

LEGEND

——— BASE TEST 1967
------ PLAN 3
— — — PLAN 6

SALINITY DISTRIBUTION

PLANS 3 AND 6
STATION 2V



MODEL TEST DATA

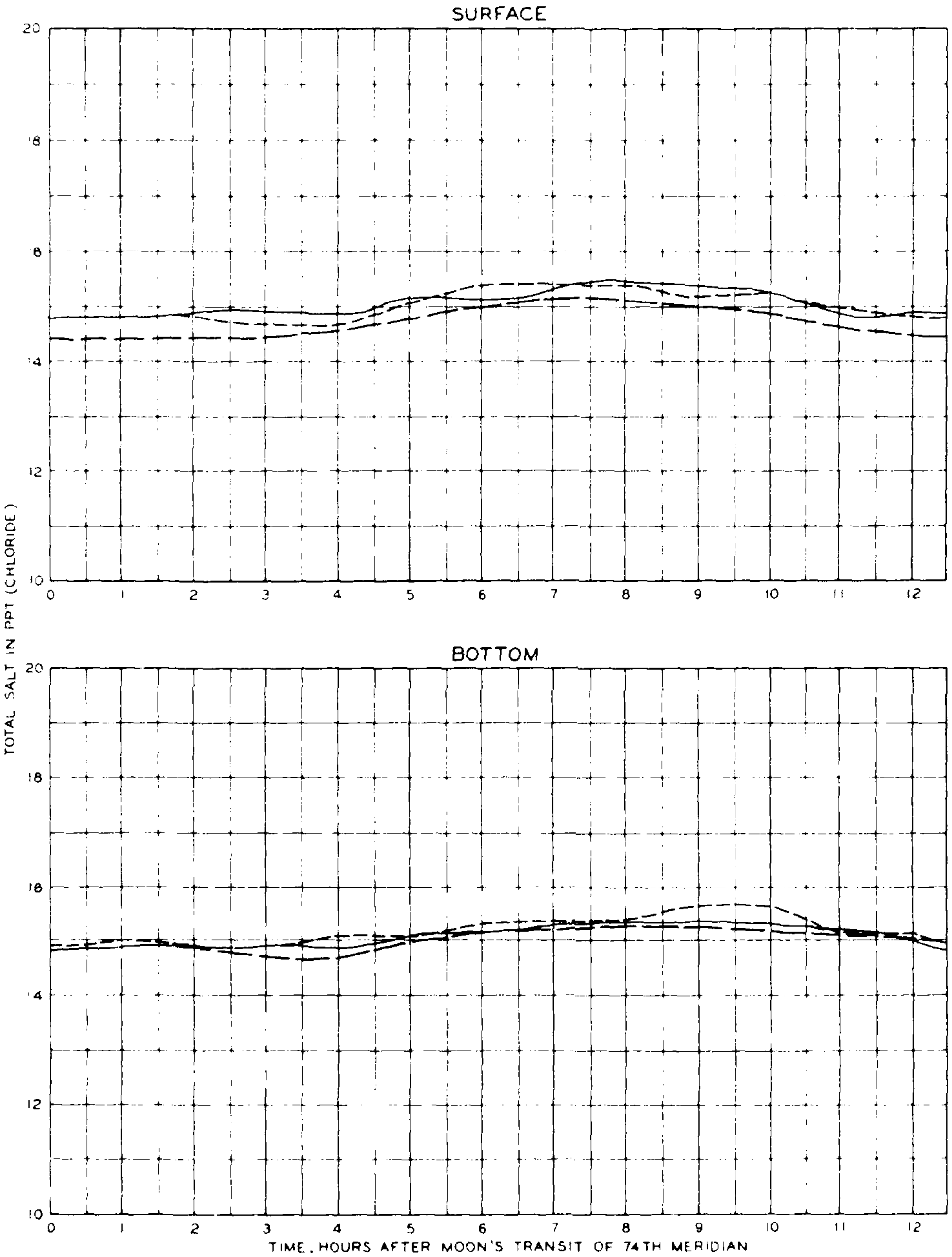
TIDE . . . . MEAN
FRESHWATER DISCHARGE 12,000 CFS (MEAN)
OCEAN SALINITY . . . . 30,000 PPM

LEGEND

——— BASE TEST 1967
- - - - - PLAN 3
— — — PLAN 6

SALINITY DISTRIBUTION

PLANS 3 AND 6
STATION 3V



MODEL TEST DATA

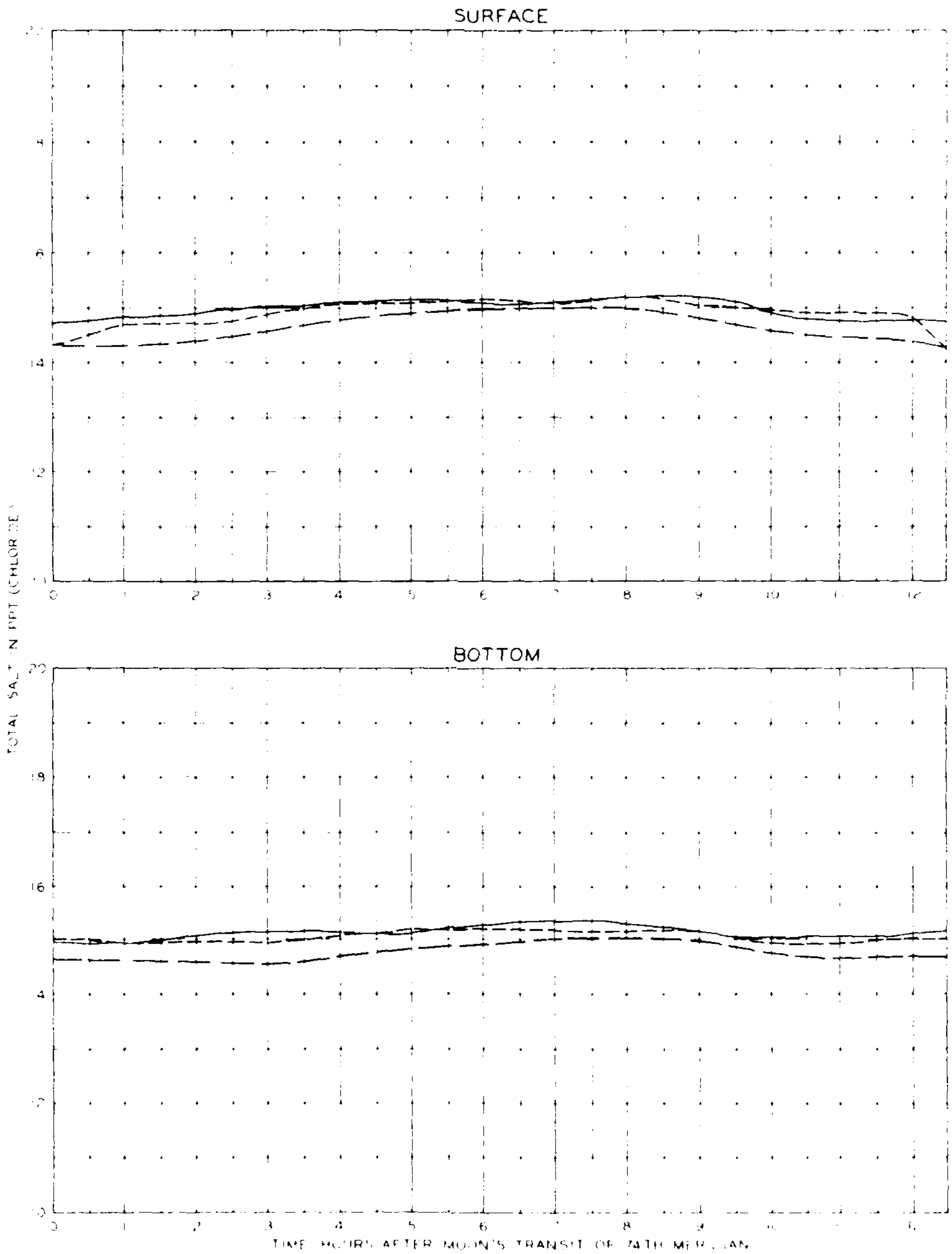
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

- ——— BASE TEST 1967
- - - - - - PLAN 3
- — — — PLAN 6

SALINITY DISTRIBUTION

PLANS 3 AND 6
STATION 4V



MODEL TEST DATA

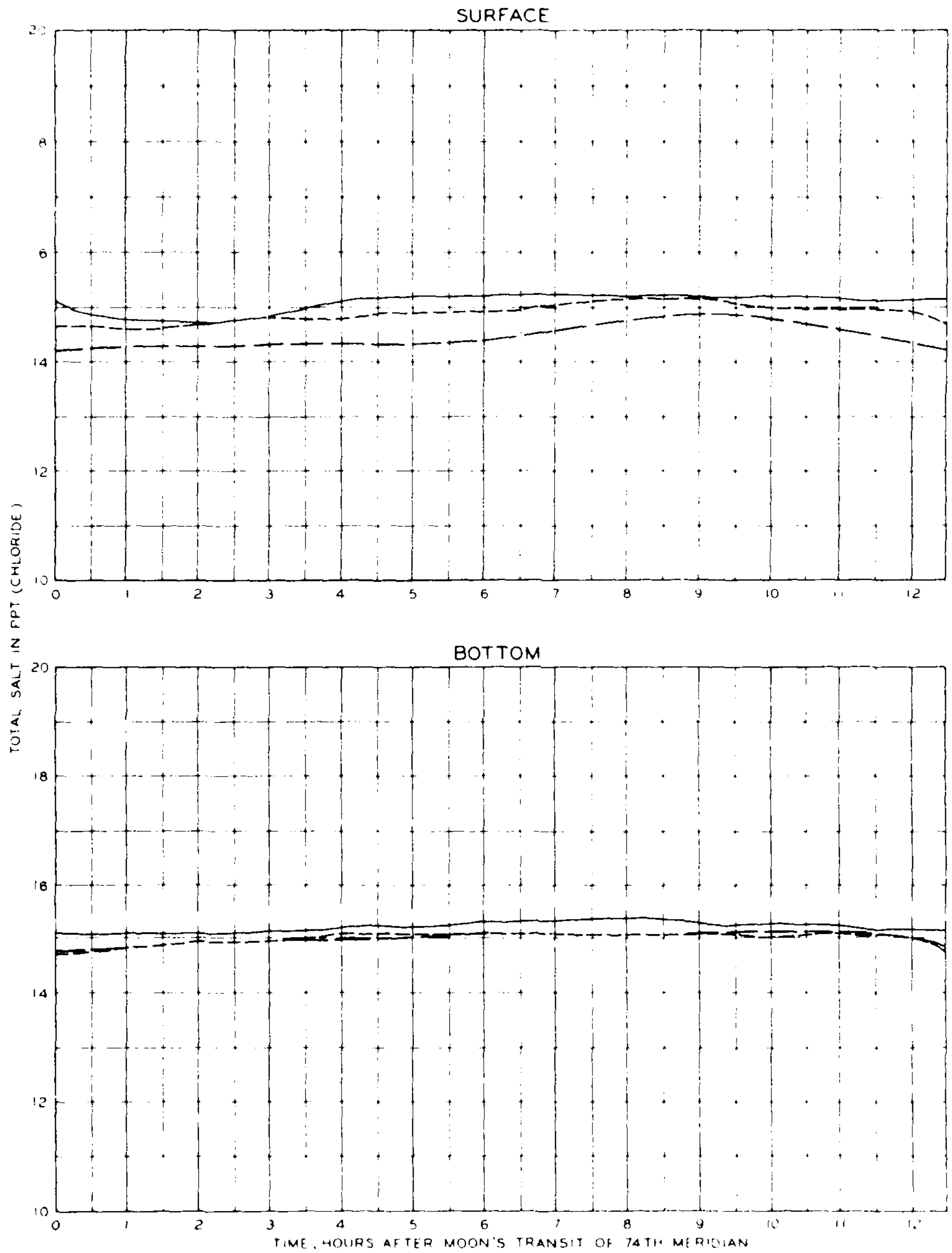
TIDE MEAN
FRESHWATER DISCHARGE 12,000 C F S (MEAN)
OCEAN SALINITY 30,000 PPM

LEGEND

——— BASE TEST 1967
------ PLAN 3
— — — PLAN 6

SALINITY DISTRIBUTION

PLANS 3 AND 6
STATION 5V



MODEL TEST DATA

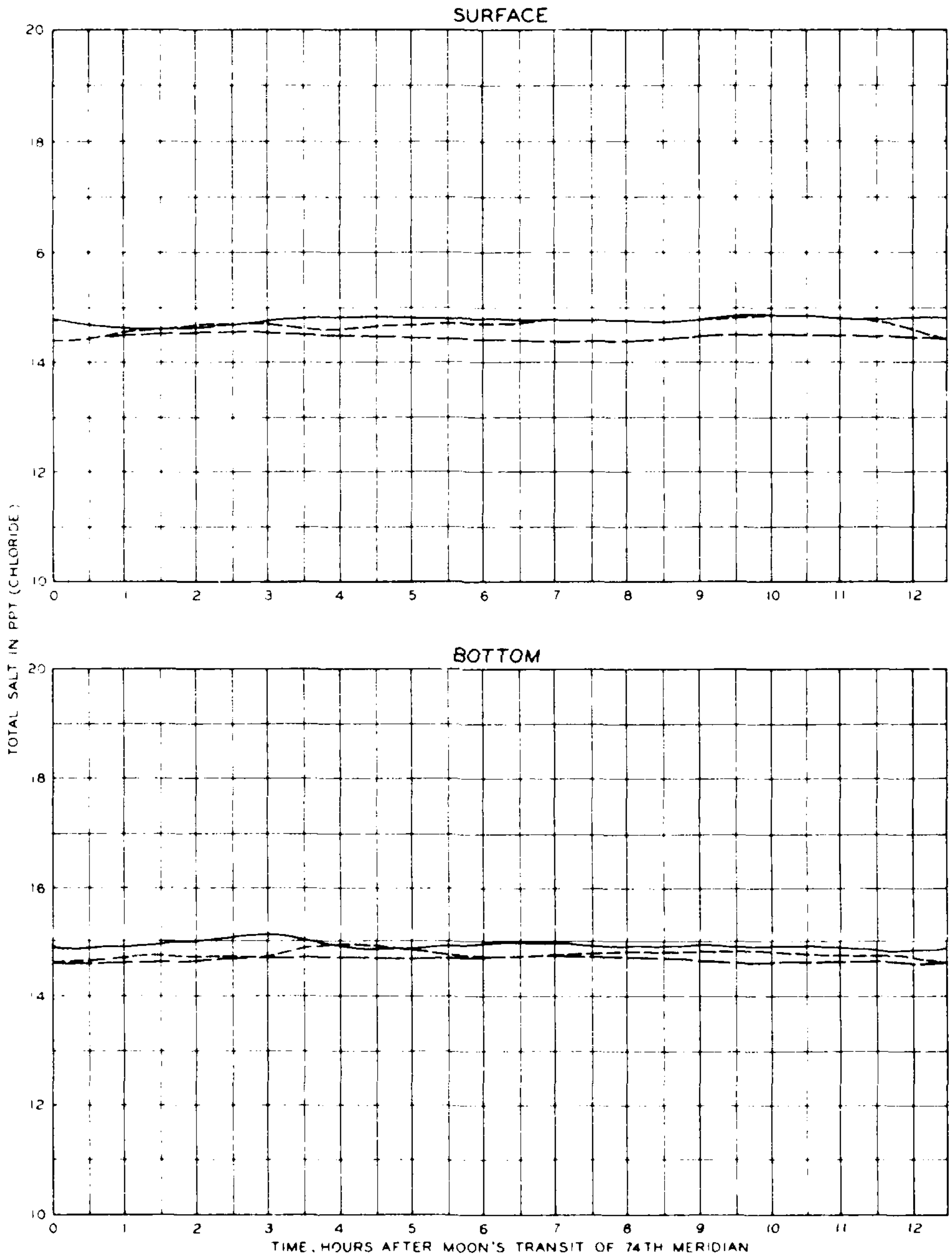
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— BASE TEST 1967
- - - - PLAN 3
— — — PLAN 6

SALINITY DISTRIBUTION

PLANS 3 AND 6
STATION 6V



MODEL TEST DATA

TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

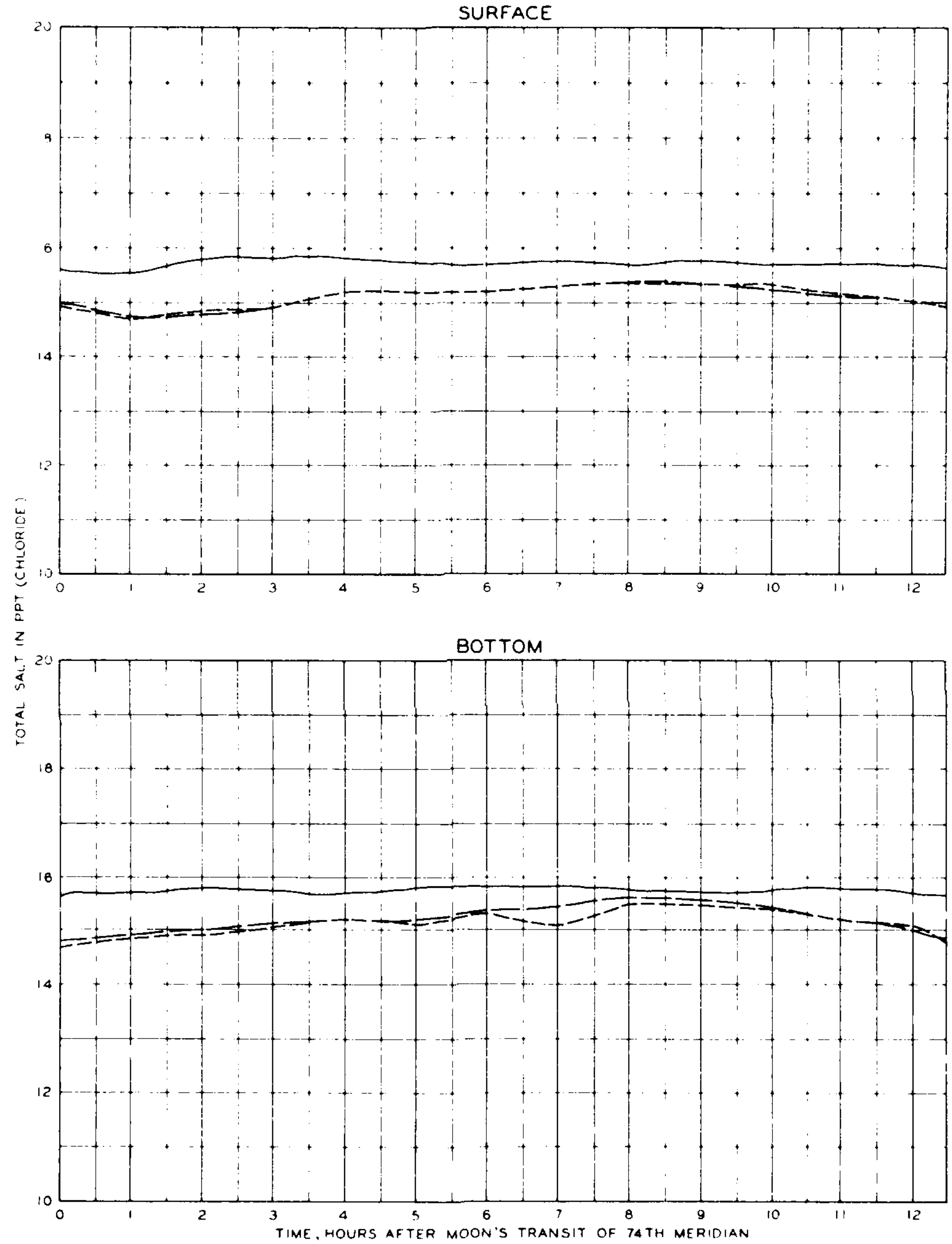
LEGEND

——— BASE TEST 1967
- - - - - PLAN 3
— — — PLAN 6

SALINITY DISTRIBUTION

PLANS 3 AND 6
STATION 7V

PLATE 64



MODEL TEST DATA

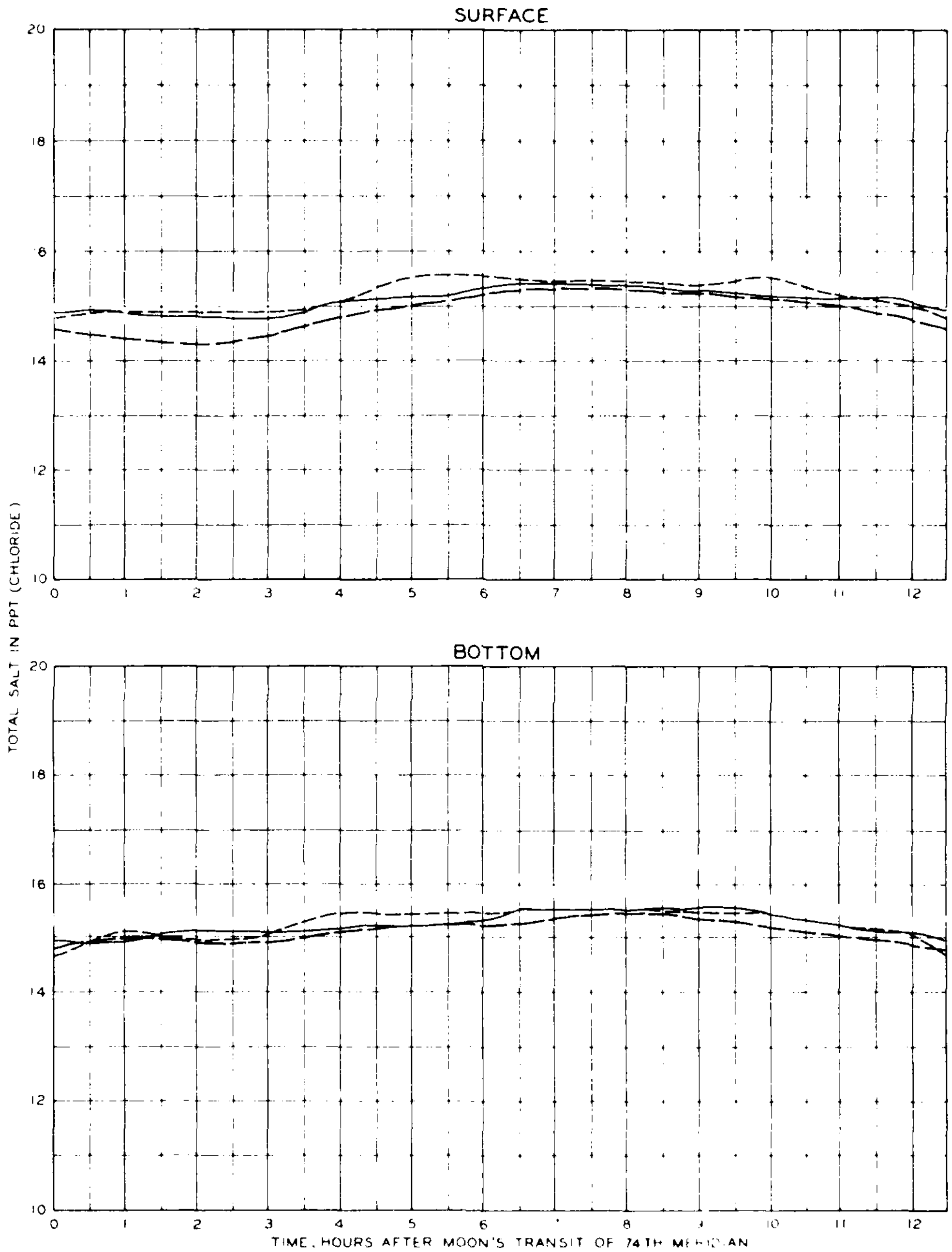
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

—— BASE TEST 1967
------ PLAN 3
— — — PLAN 6

SALINITY DISTRIBUTION

PLANS 3 AND 6
STATION O BCH



MODEL TEST DATA

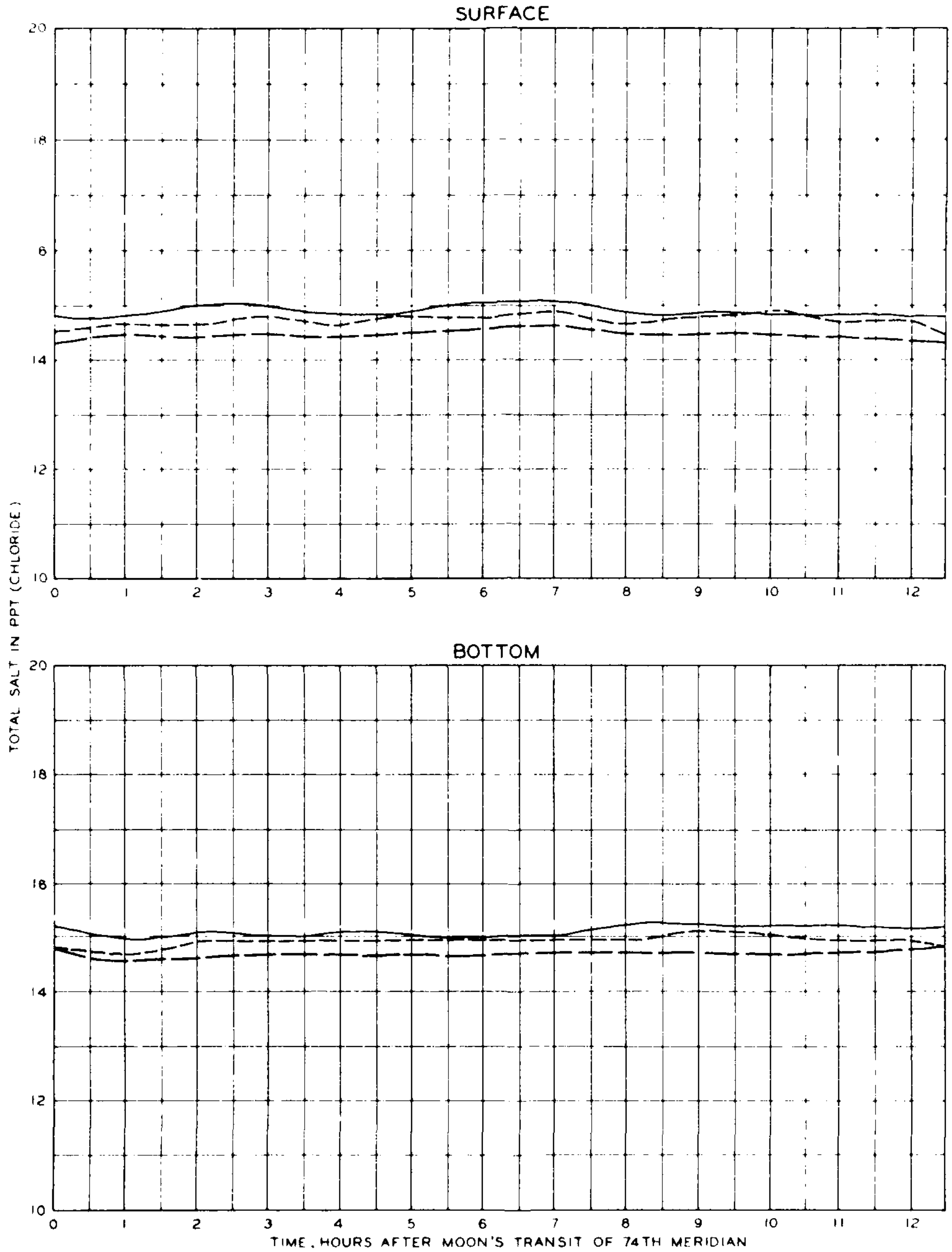
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

- BASE TEST 1967
- PLAN 3
- PLAN 6

SALINITY DISTRIBUTION

PLANS 3 AND 6
STATION 1BCH



MODEL TEST DATA

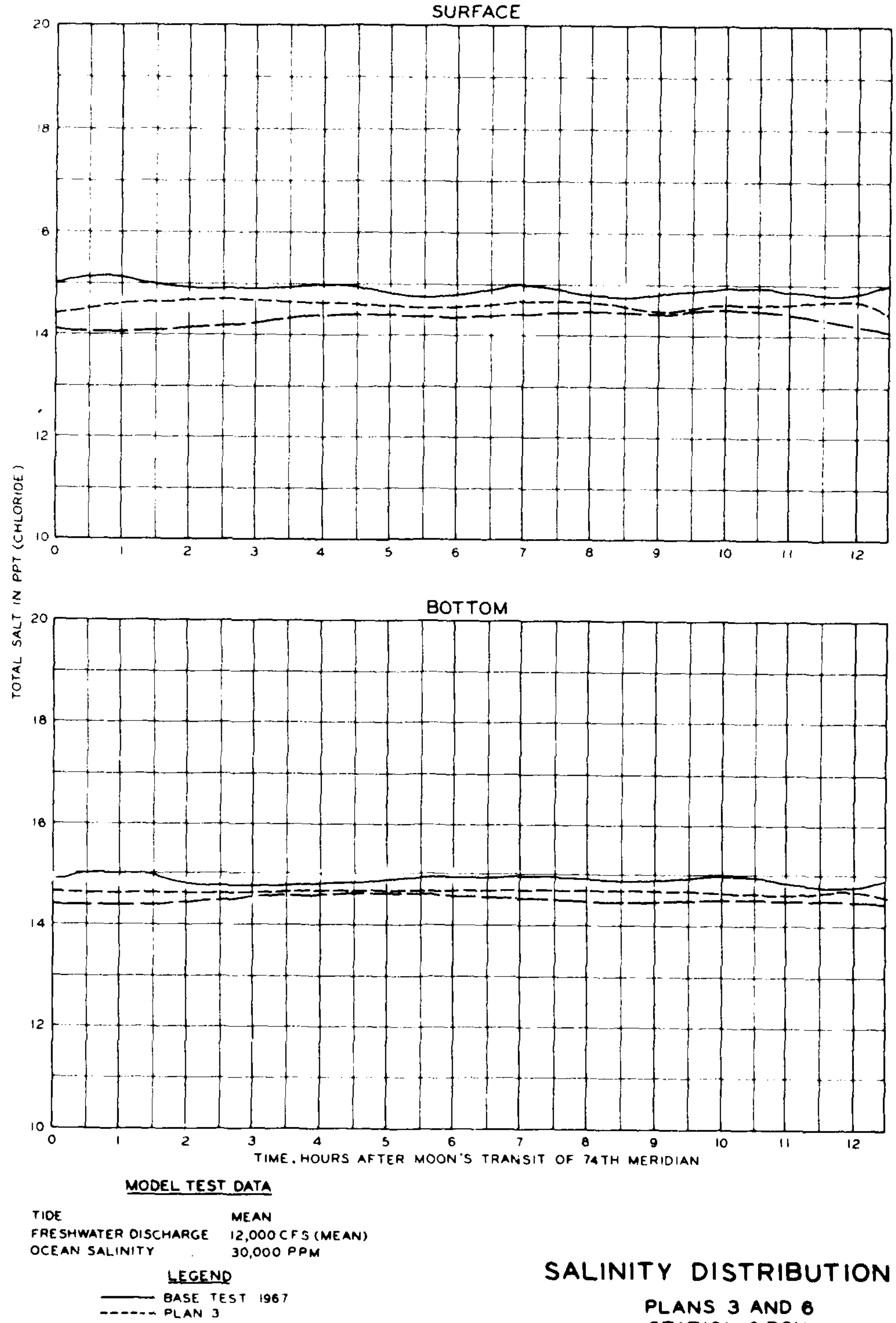
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— BASE TEST 1967
------ PLAN 3
— — — PLAN 6

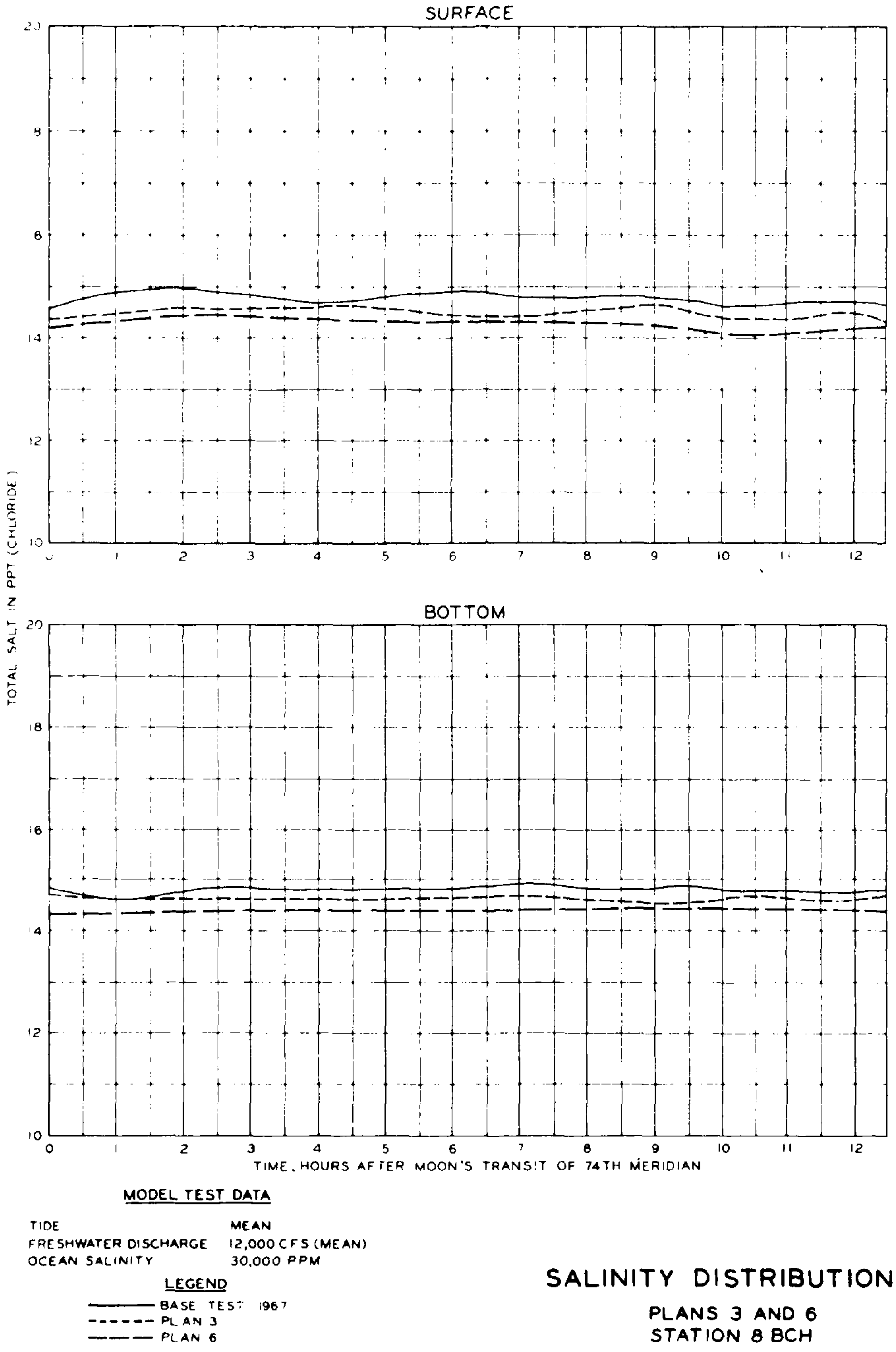
SALINITY DISTRIBUTION

PLANS 3 AND 6
STATION 4 BCH



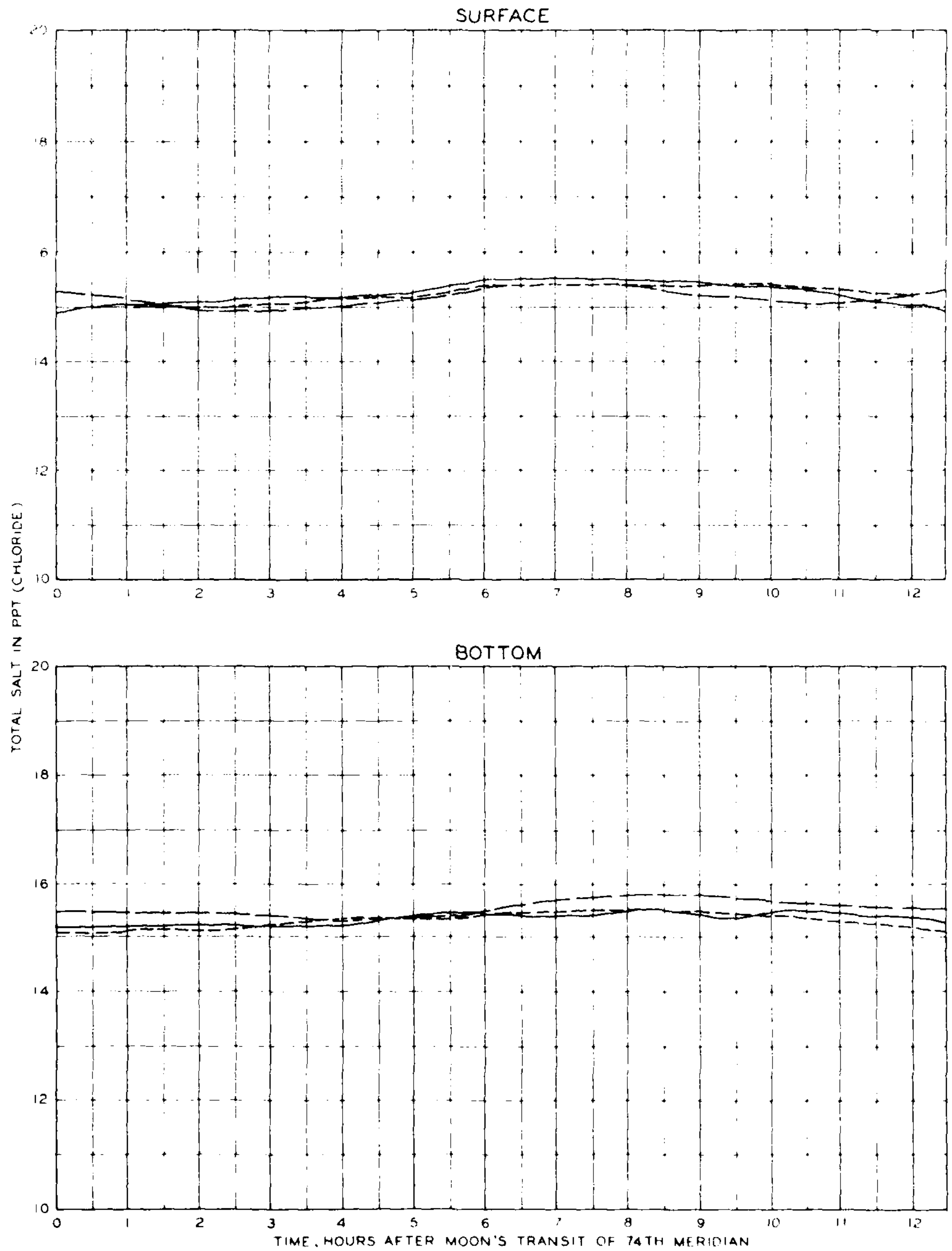
SALINITY DISTRIBUTION

PLANS 3 AND 6
STATION 6 BCH



SALINITY DISTRIBUTION

PLANS 3 AND 6
STATION 8 BCH



MODEL TEST DATA

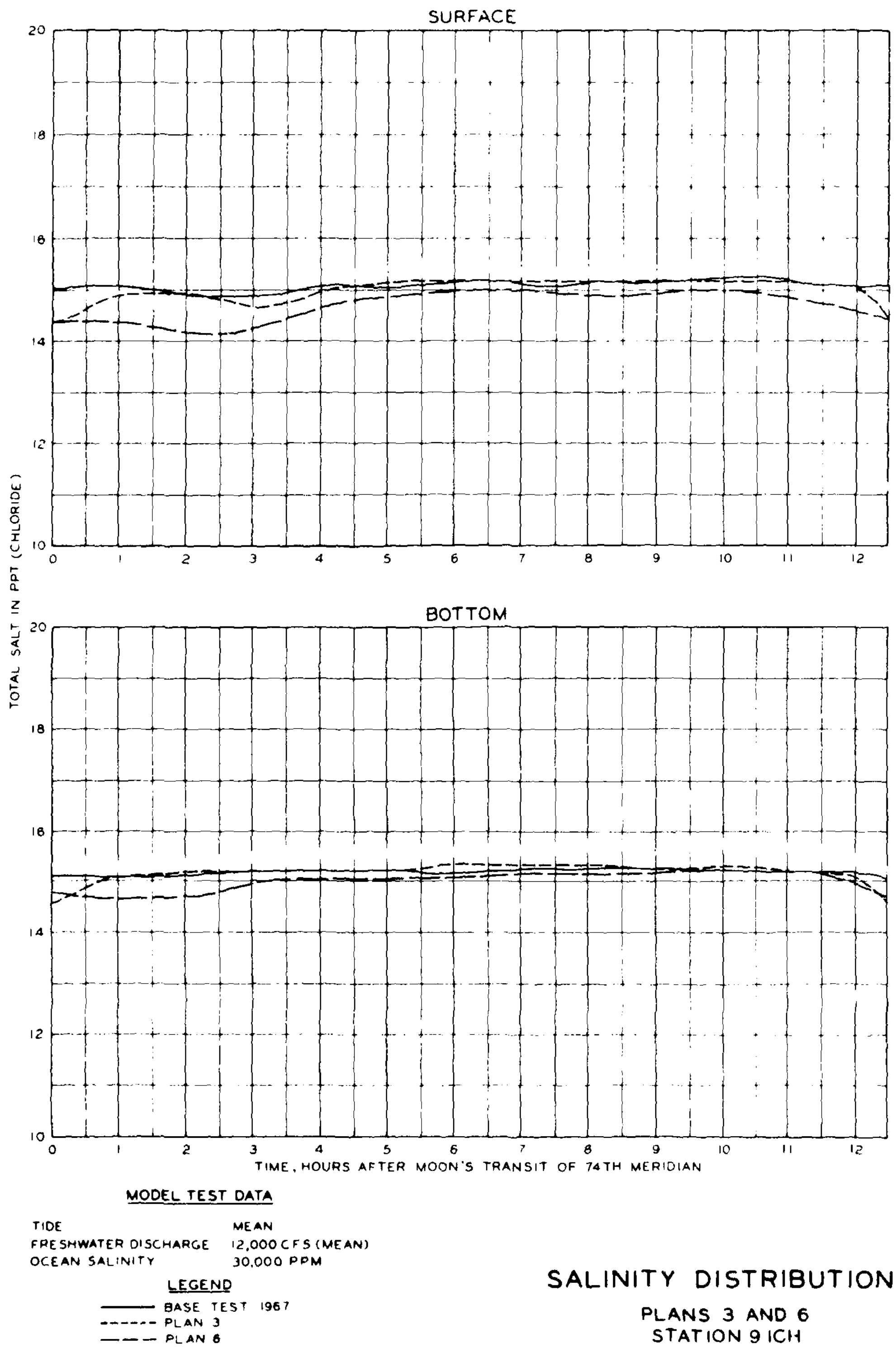
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— BASE TEST 1967
------ PLAN 3
— — — PLAN 6

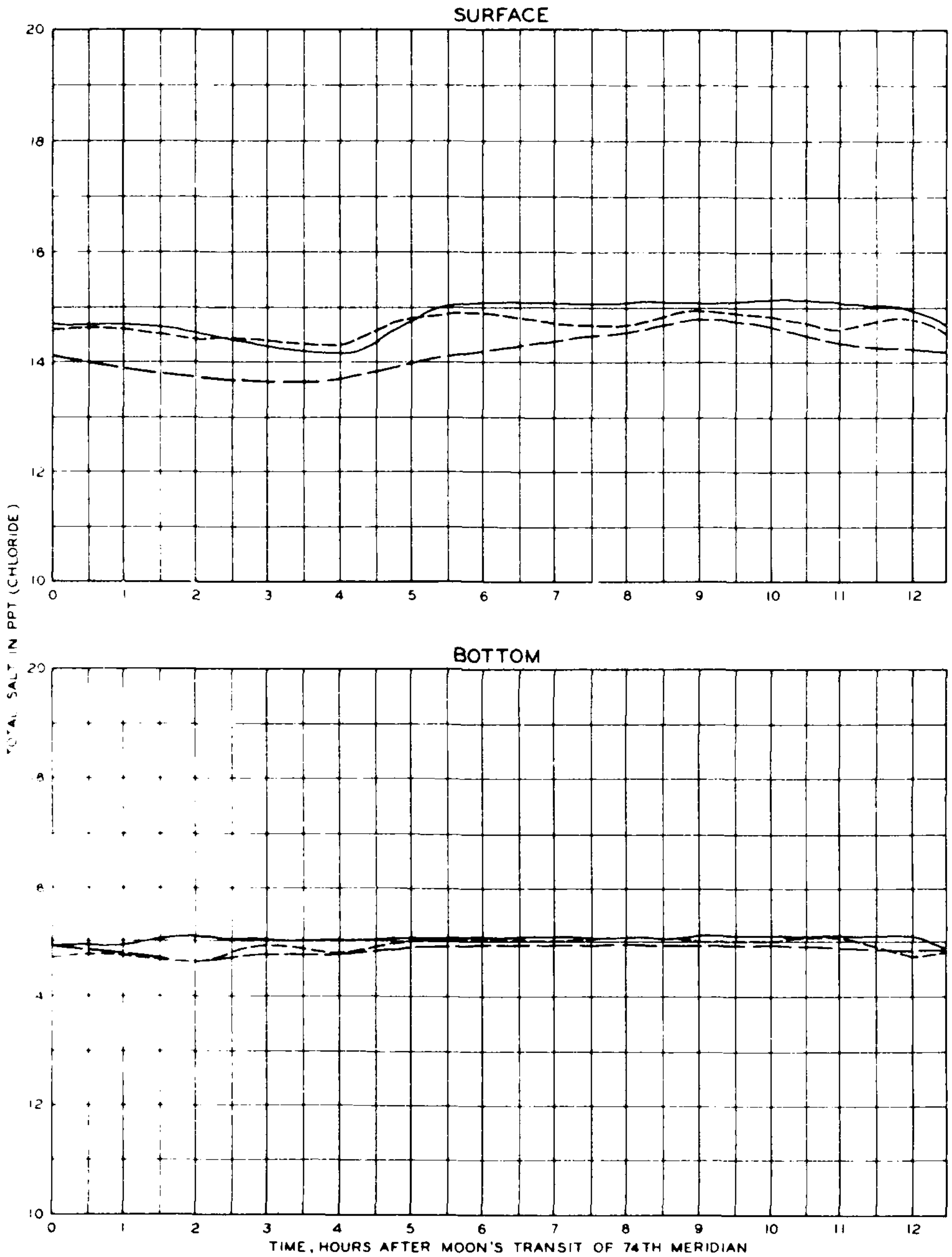
SALINITY DISTRIBUTION

PLANS 3 AND 6
STATION 7 ICH



SALINITY DISTRIBUTION

PLANS 3 AND 6
STATION 9 ICH



MODEL TEST DATA

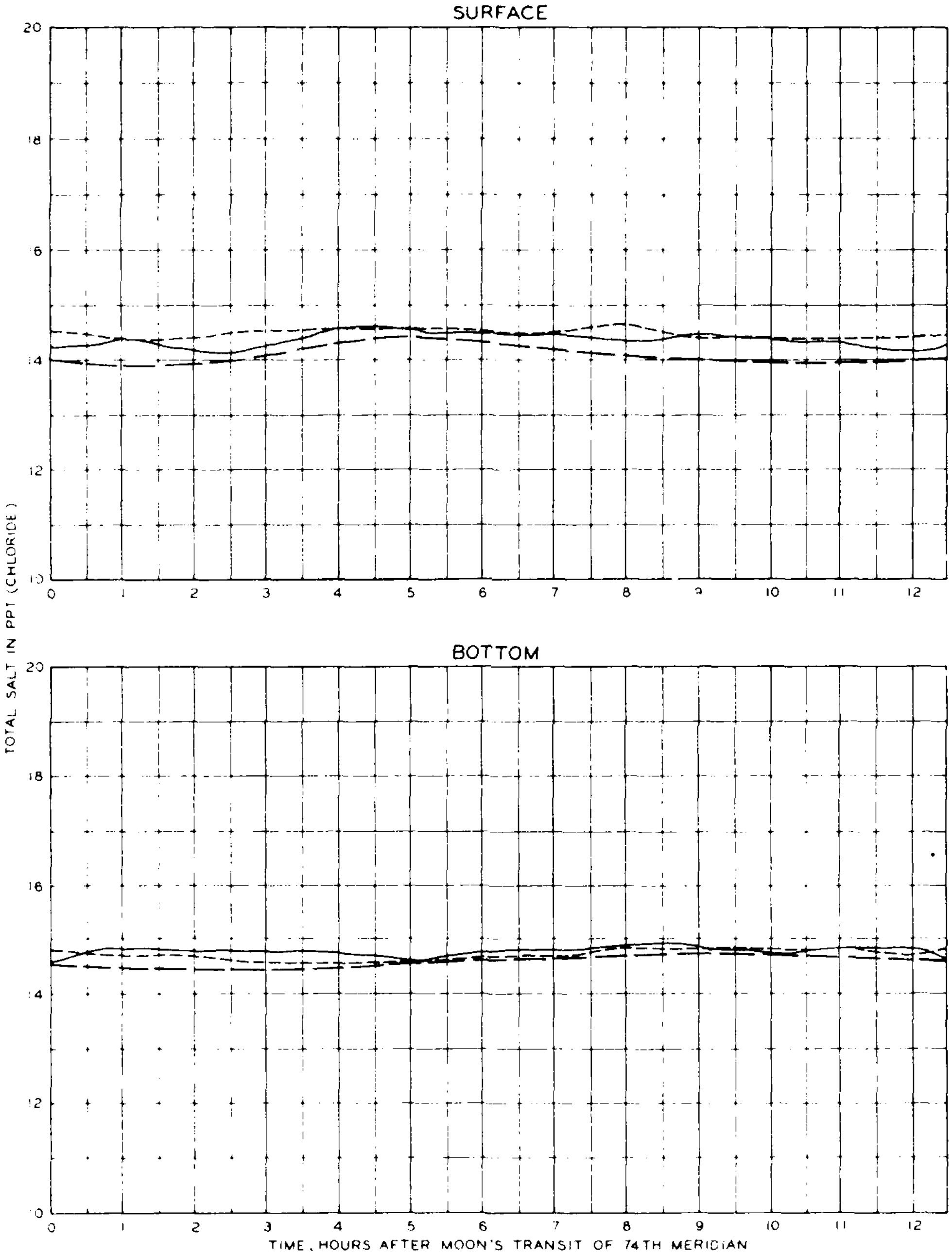
TIDE	MEAN
FRESHWATER DISCHARGE	12,000 CFS (MEAN)
OCEAN SALINITY	30,000 PPM

LEGEND

——— BASE TEST 1967
- - - - - PLAN 3
— — — PLAN 6

SALINITY DISTRIBUTION

PLANS 3 AND 6
STATION 11 ICH



MODEL TEST DATA

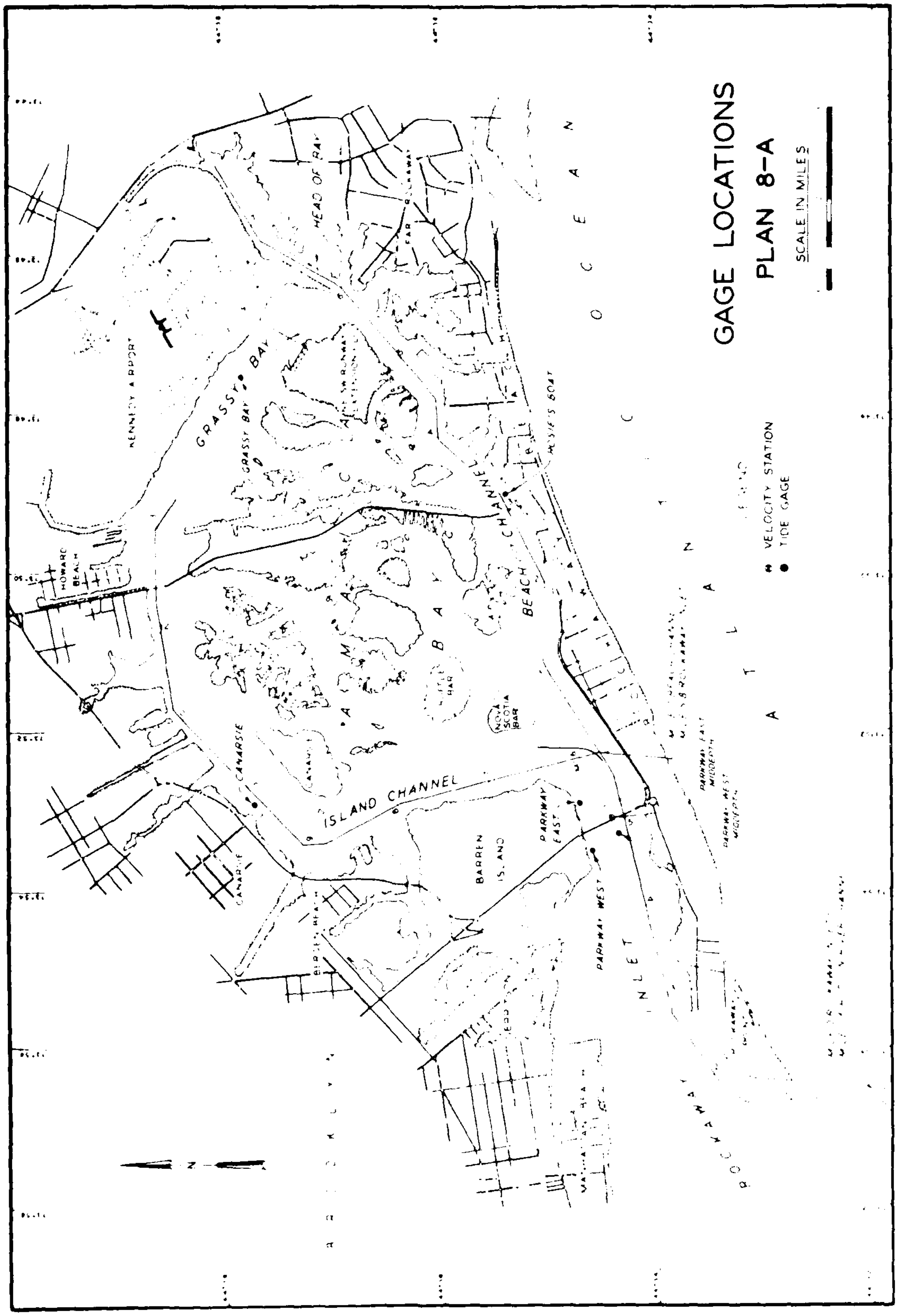
TIDE MEAN
FRESHWATER DISCHARGE 12,000 CFS (MEAN)
OCEAN SALINITY 30,000 PPM

LEGEND

——— BASE TEST 1967
------- PLAN 3
— — — PLAN 6

SALINITY DISTRIBUTION

PLANS 3 AND 6
STATION 13 ICH



GAGE LOCATIONS
PLAN 8-A
SCALE IN MILES
VELOCITY STATION
TIDE GAGE
KENNEDY AIRPORT
GRASSY BAY
HEAD OF BAY
HOWARD BEACH
CANARSIE
ISLAND CHANNEL
BARREN ISLAND
PARKWAY EAST
PARKWAY WEST
NOVA SCOTIA BAR
BEACH CHANNEL
INLET
ATLANTIC OCEAN

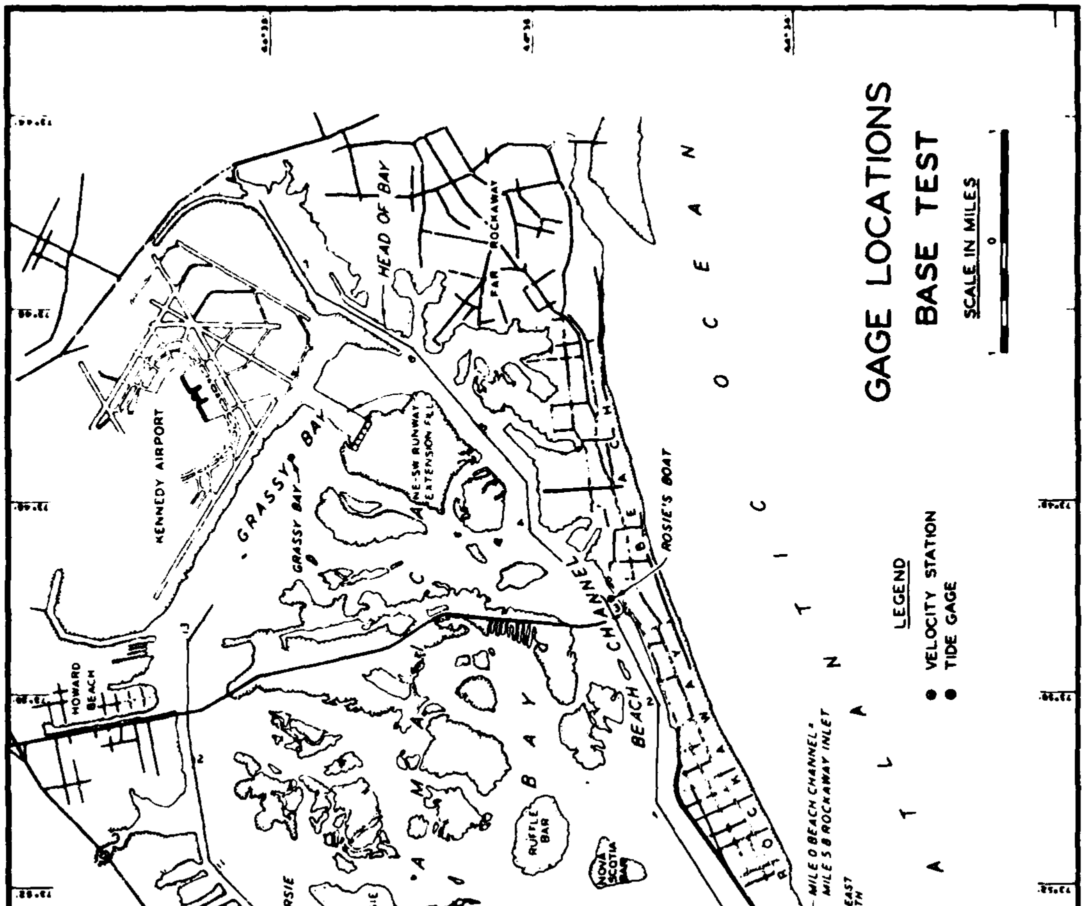
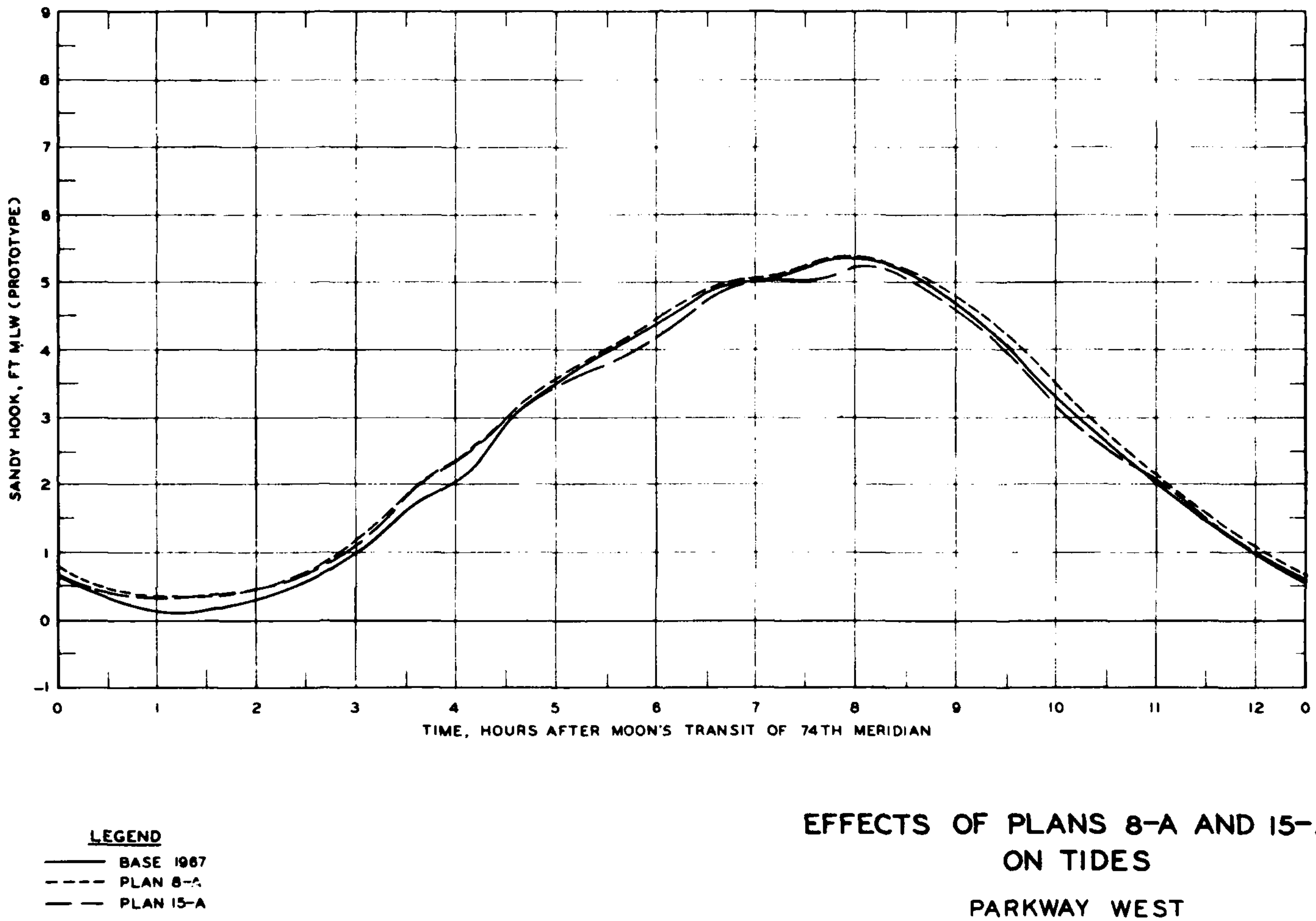
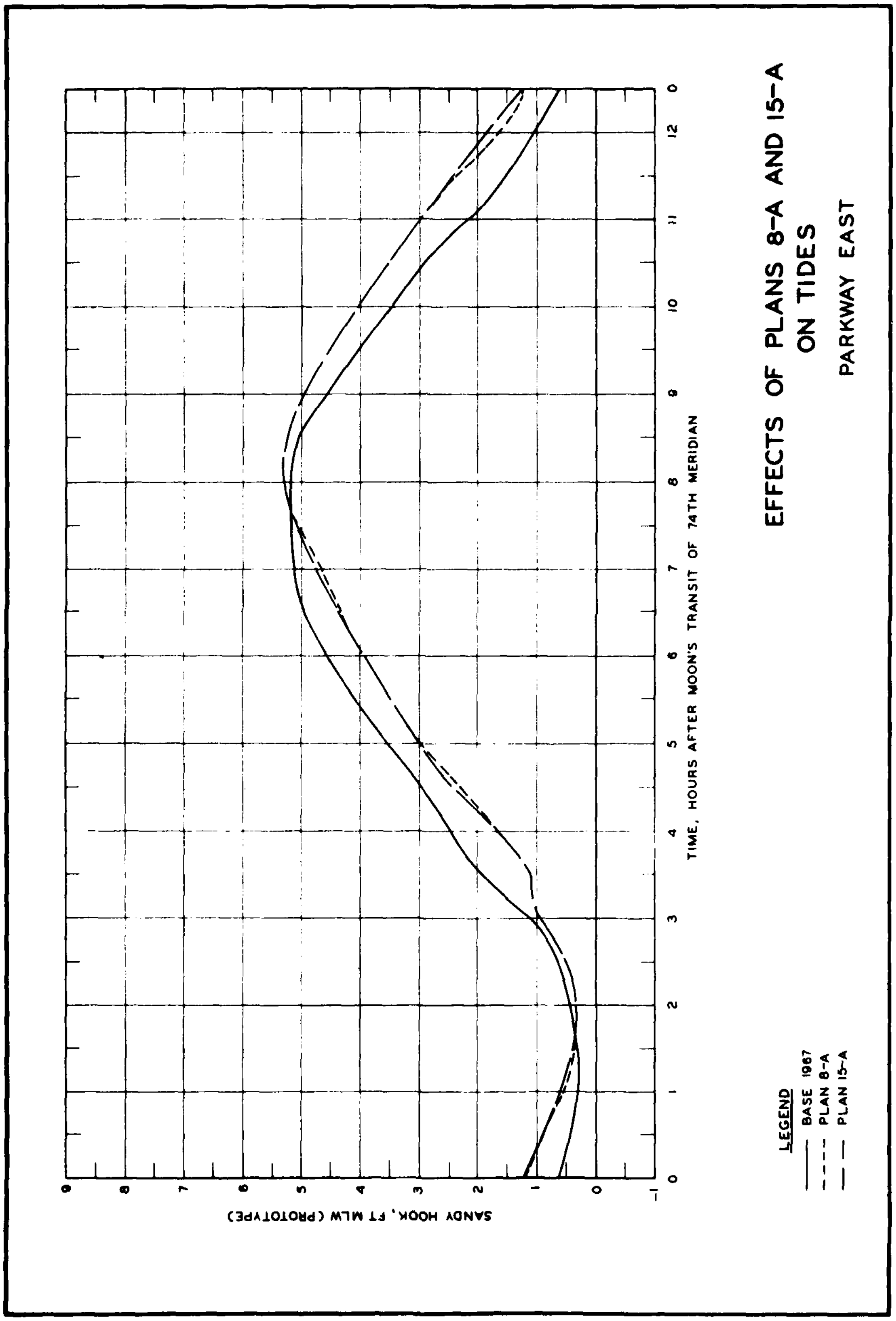

GAGE LOCATIONS
BASE TEST
SCALE IN MILES
0
LEGEND
VELOCITY STATION
TIDE GAGE
KENNEDY AIRPORT
GRASSY BAY
GRASSY BAY
NE-SW RUNWAY EXTENSION FILL
HEAD OF BAY
FAR ROCKAWAY
HOWARD BEACH
J A M A I C A
BAY
BEACH CHANNEL
ROSIE'S BOAT
RUFFLE BAR
NOVA SCOTIA BAR
CANARSIE
CANARSIE
CANARSIE
ISLAND CHANNEL
BARREN ISLAND
PARKWAY EAST
PARKWAY WEST
MILE 0 BEACH CHANNEL = MILE 5.8 ROCKAWAY INLET
PARKWAY EAST MIDDEPTH
PARKWAY WEST MIDDEPTH
BERGEN BEACH
GERRITSON
MANHATTAN BEACH
ROCKAWAY POINT
MILE 0 ROCKAWAY INLET = MILE -16 HUDSON RIVER CHANNEL
R O C K A W A Y
INLET
A T L A N T I C
O C E A N
B R O O K L Y N
N

PLATE 76

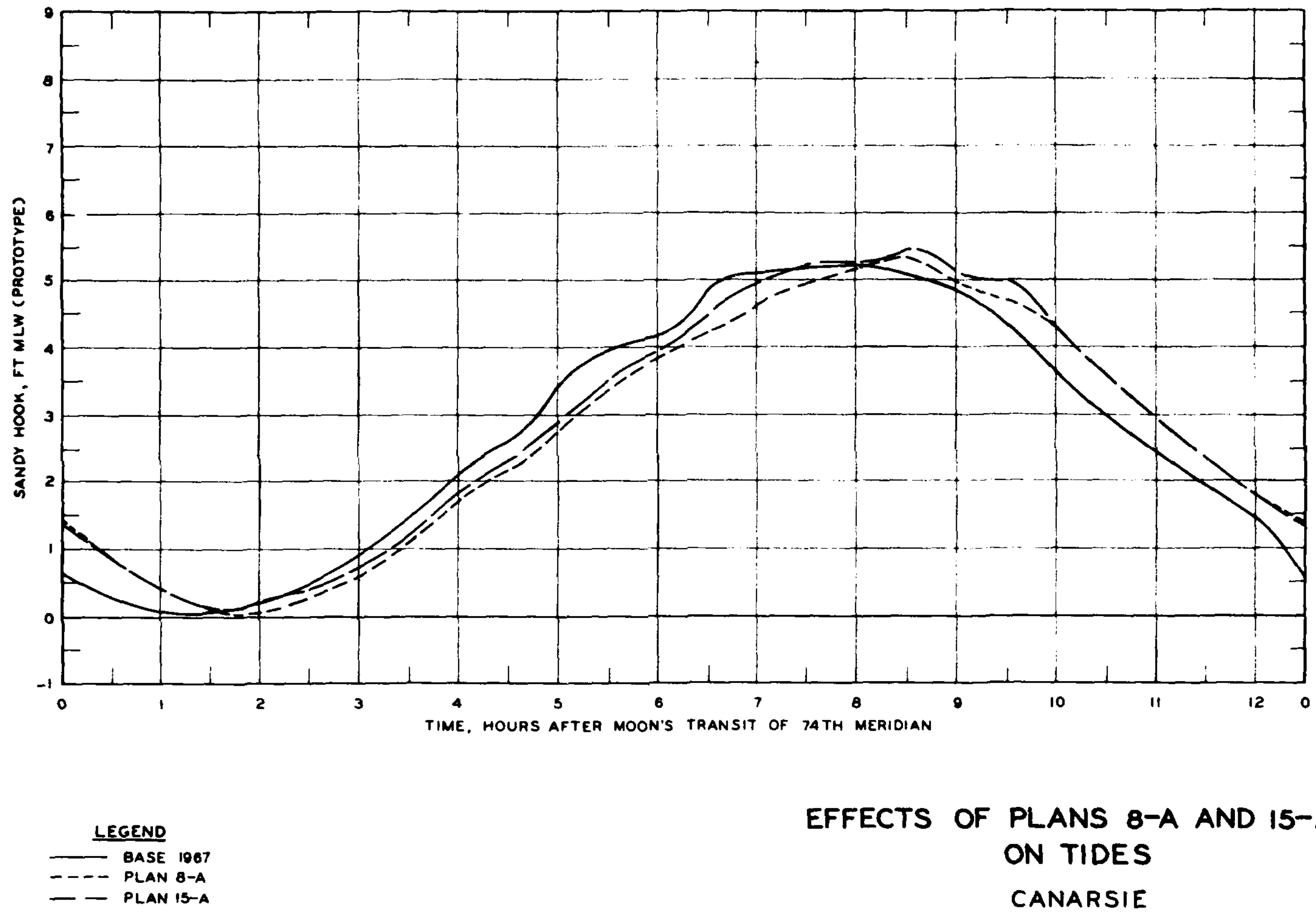


EFFECTS OF PLANS 8-A AND 15-A
ON TIDES

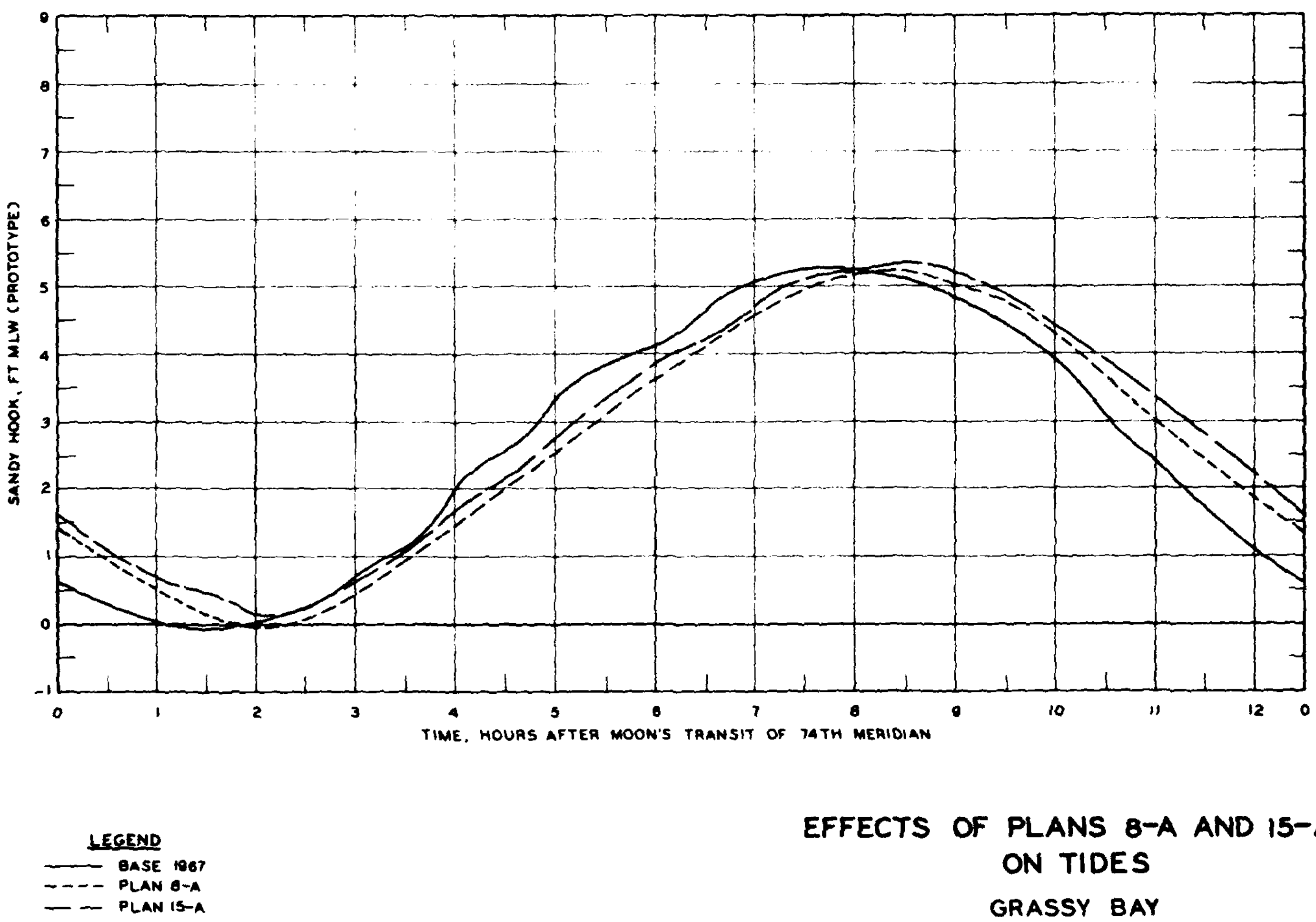
PARKWAY WEST



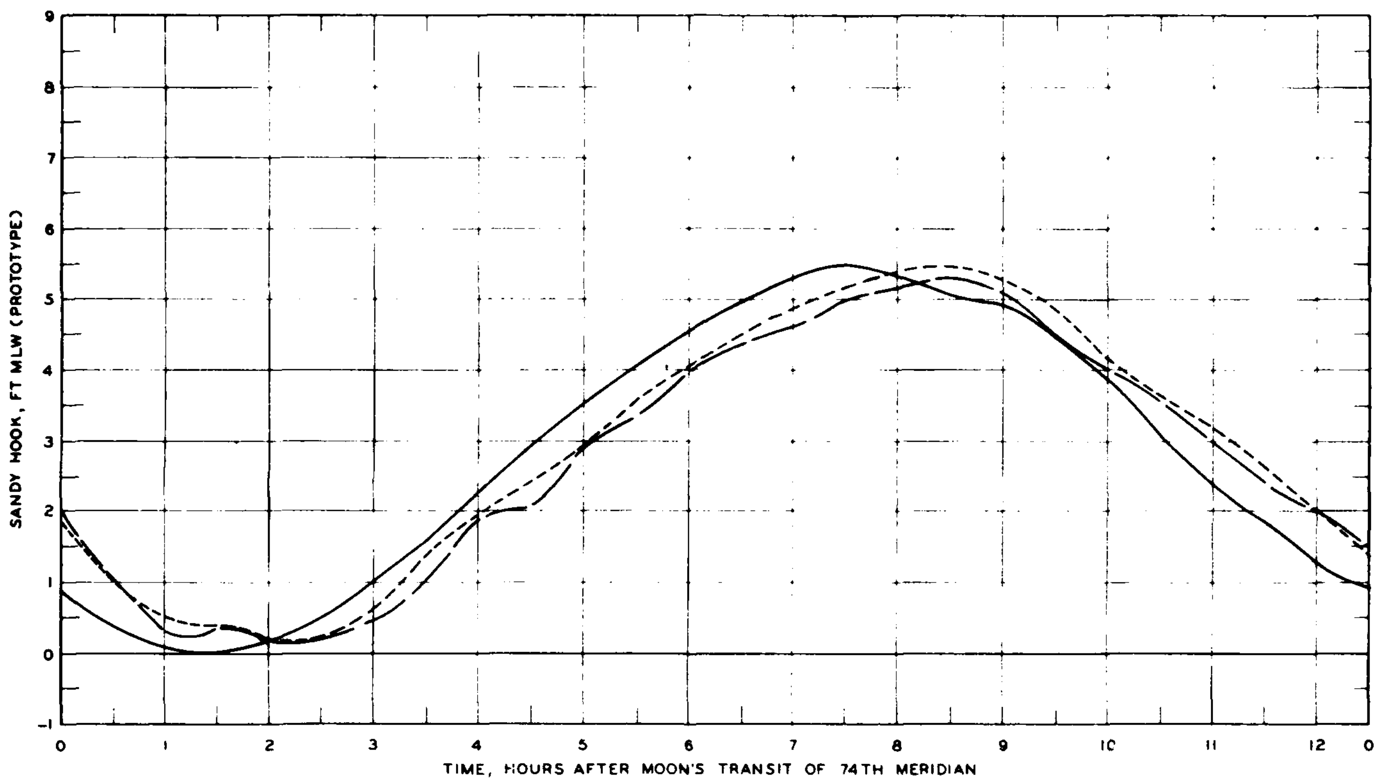
EFFECTS OF PLANS 8-A AND 15-A
ON TIDES
PARKWAY EAST



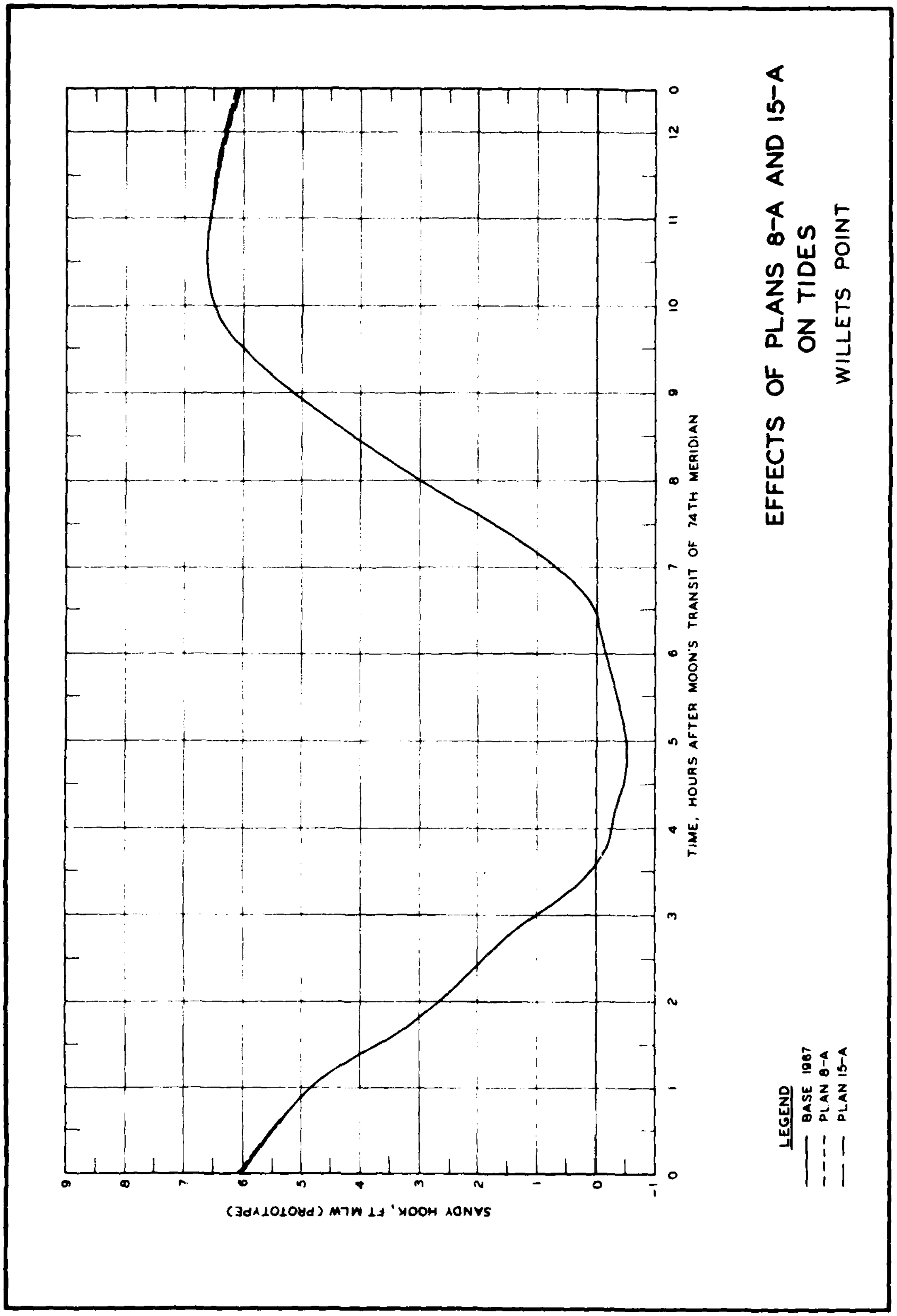
EFFECTS OF PLANS 8-A AND 15-A
ON TIDES
CANARSIE



EFFECTS OF PLANS 8-A AND 15-A
ON TIDES
GRASSY BAY

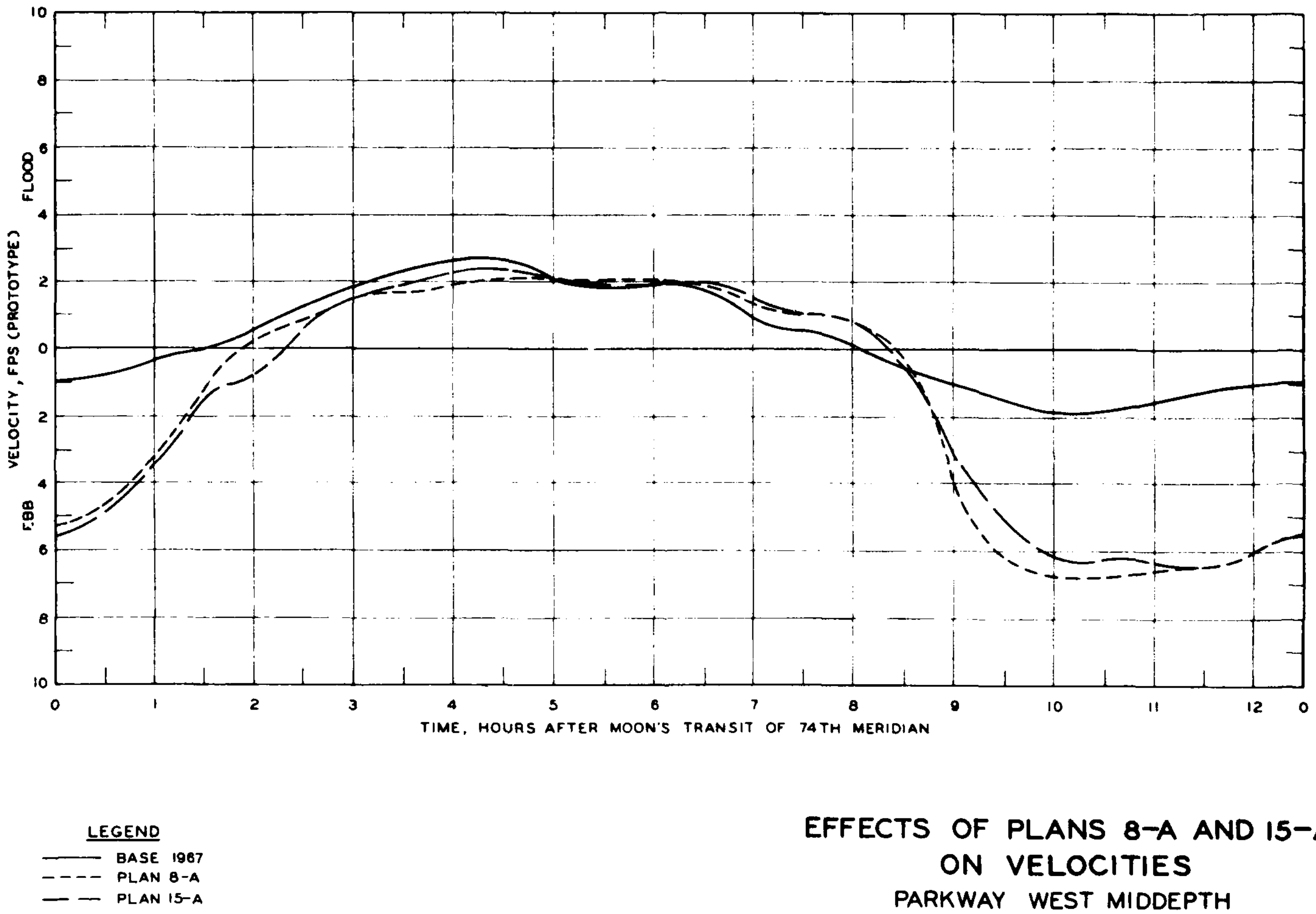


EFFECTS OF PLANS 8-A AND 15-A
ON TIDES
ROSIE'S BOATS



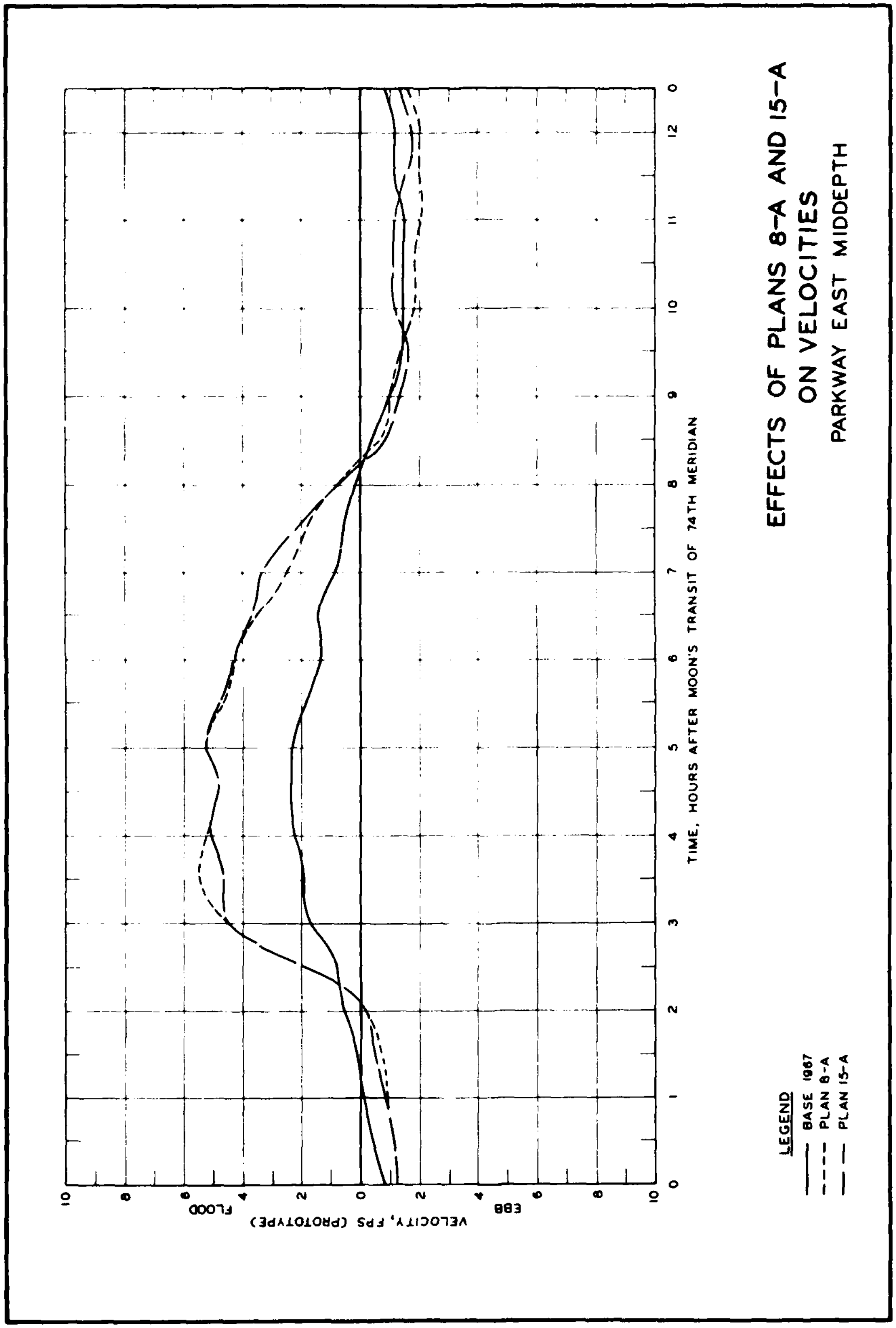
EFFECTS OF PLANS 8-A AND 15-A ON TIDES
WILLETS POINT

PLATE 82



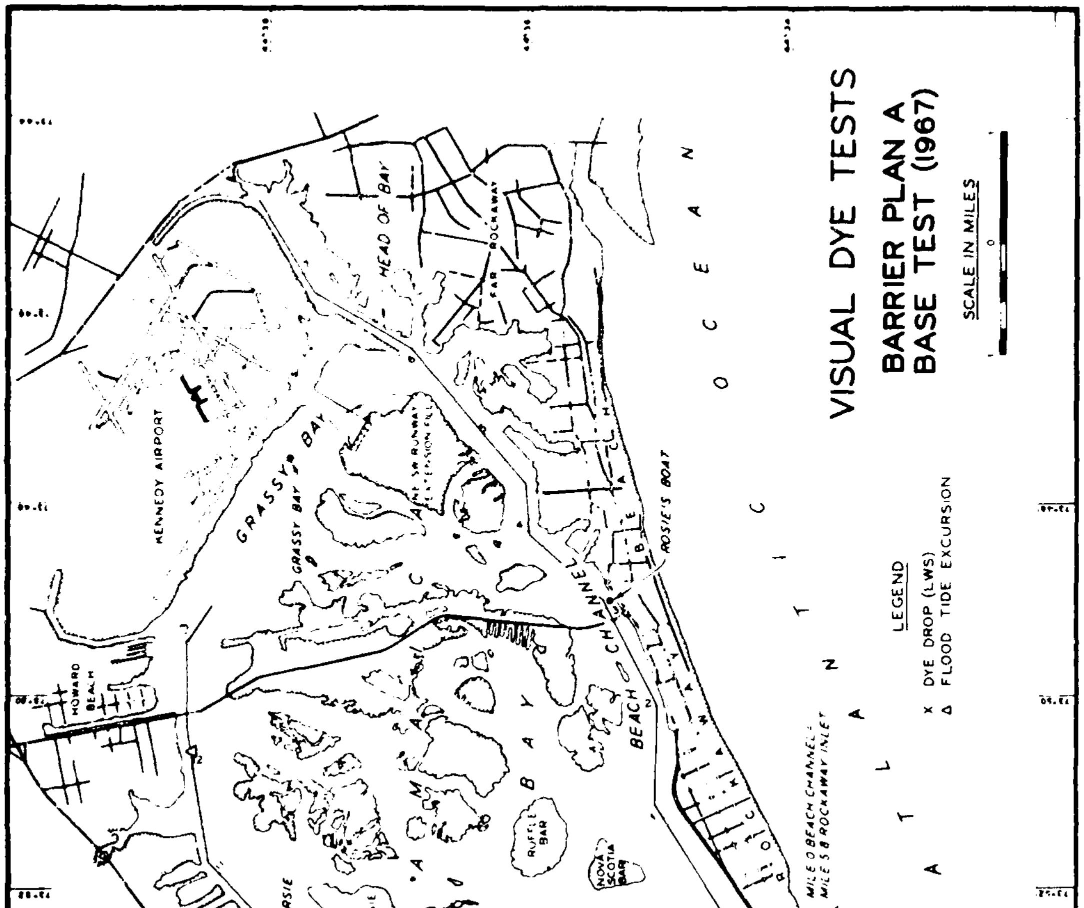
EFFECTS OF PLANS 8-A AND 15-A ON VELOCITIES

PARKWAY WEST MIDDEPTH



EFFECTS OF PLANS 8-A AND 15-A
ON VELOCITIES
PARKWAY EAST MIDDEPTH

PLATE 84


VISUAL DYE TESTS
BARRIER PLAN A
BASE TEST (1967)
SCALE IN MILES
LEGEND
X DYE DROP (LWS)
Δ FLOOD TIDE EXCURSION
KENNEDY AIRPORT
GRASSY BAY
HEAD OF BAY
FAR ROCKAWAY
HOWARD BEACH
JAMAICA BAY
BEACH CHANNEL
ROSIE'S BOAT
RUFFLE BAR
NOVA SCOTIA BAR
CANARSIE
ISLAND CHANNEL
BARREN ISLAND
PARKWAY EAST
PARKWAY WEST
BERGEN BEACH
GERRITSON
MANHATTAN BEACH
BROOKLYN
ROCKAWAY INLET
ROCKAWAY POINT
BARRIER PLAN A
MILE 0 BEACH CHANNEL = MILE 5 B ROCKAWAY INLET
MILE 0 ROCKAWAY INLET = MILE 16 HUDSON RIVER CHANNEL
ATLANTIC OCEAN
ROCKAWAY BEACH
N

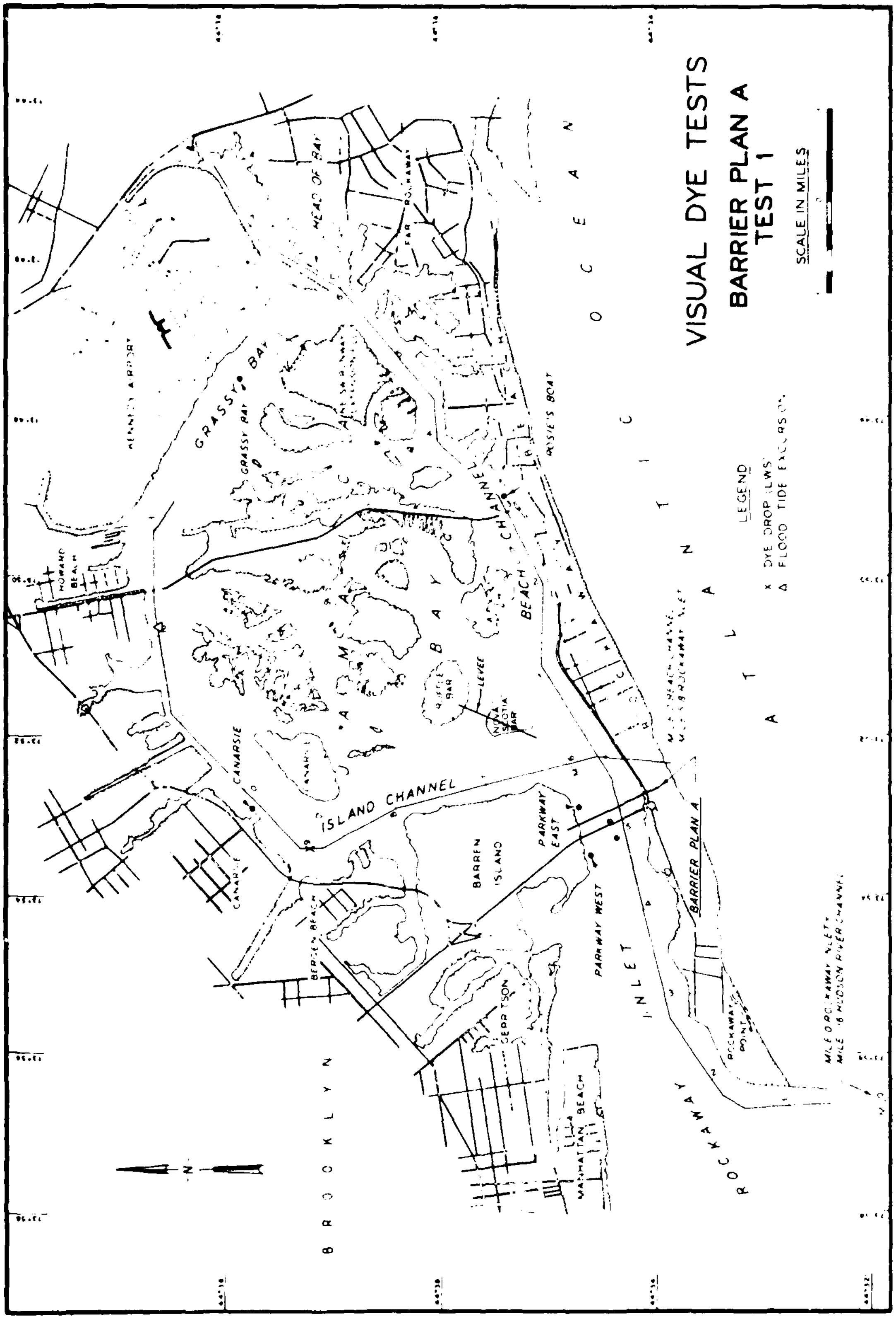

VISUAL DYE TESTS
BARRIER PLAN A
TEST 1
SCALE IN MILES
LEGEND
DYE DROP (LWS)
FLOOD TIDE EXCURSION
GRASSY BAY
KENNEDY AIRPORT
HEAD OF BAY
FAR ROCKAWAY
JAMAICA BAY
BEACH CHANNEL
ISLAND CHANNEL
CANARSIE
HOWARD BEACH
RUFFLE BAR
LEVEE
NOVA SCOTIA BAR
BARREN ISLAND
PARKWAY EAST
PARKWAY WEST
BARRIER PLAN A
BERGEN BEACH
GERRITSON
MANHATTAN BEACH
BROOKLYN
ROCKAWAY INLET
ROCKAWAY POINT
ATLANTIC OCEAN
N

PLATE 86

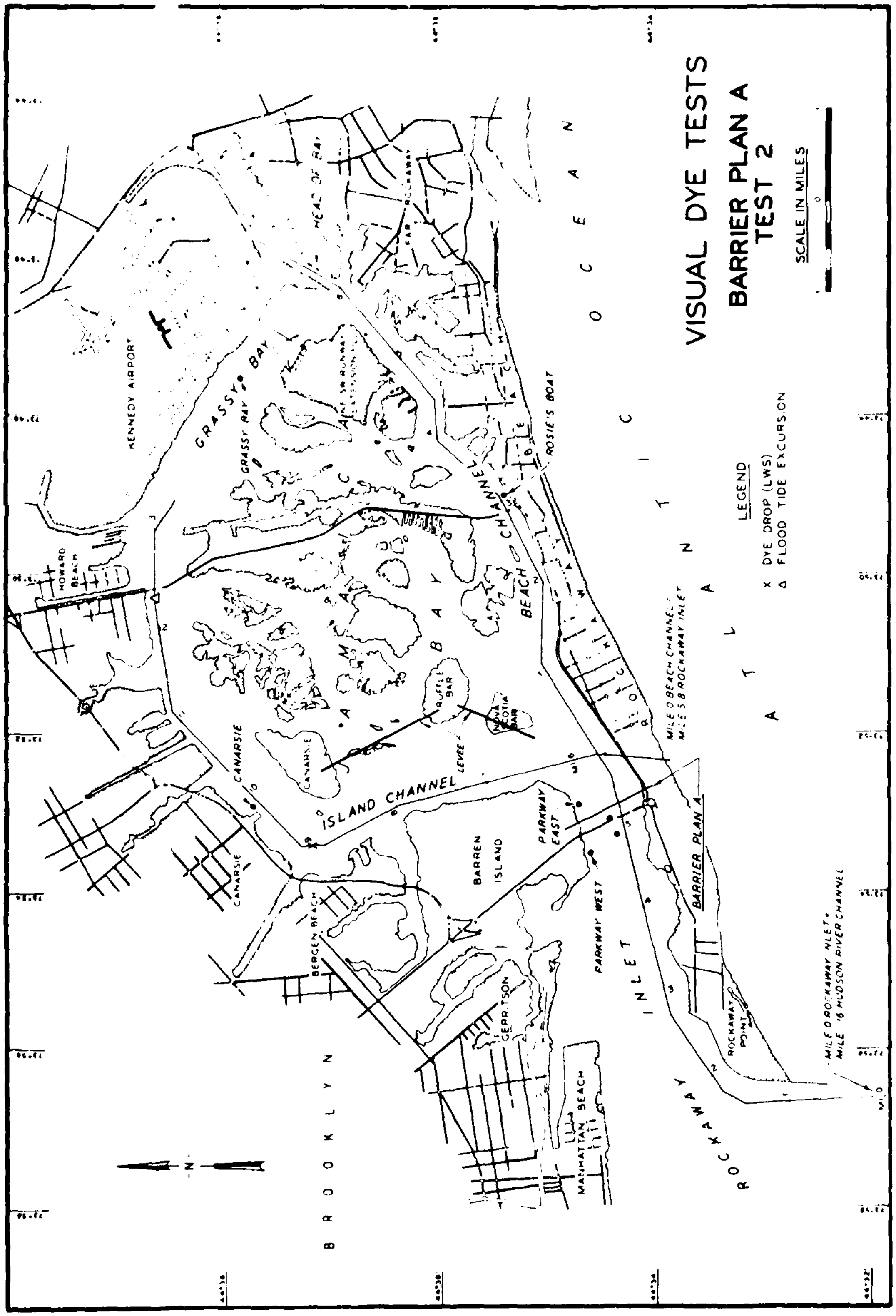
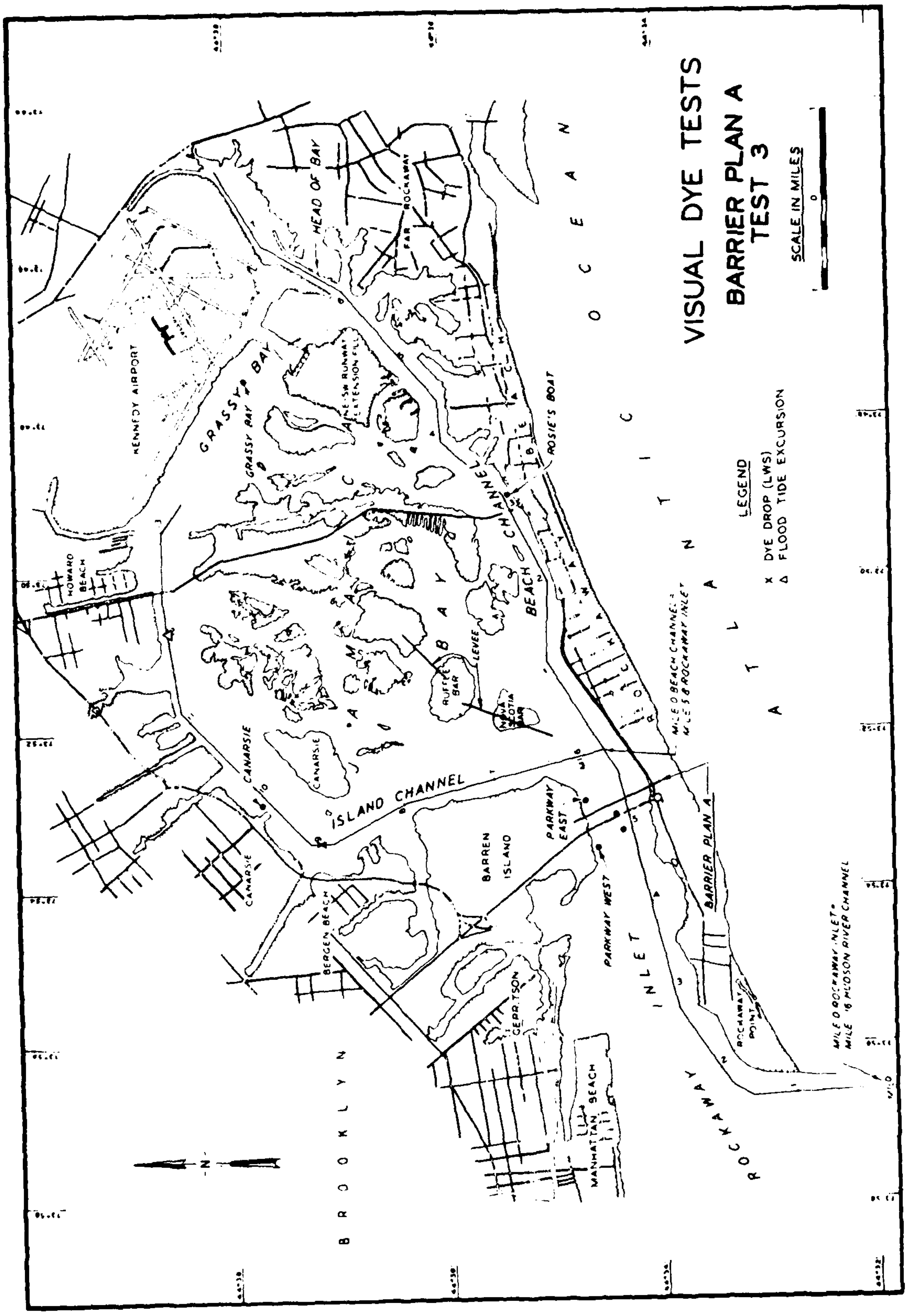
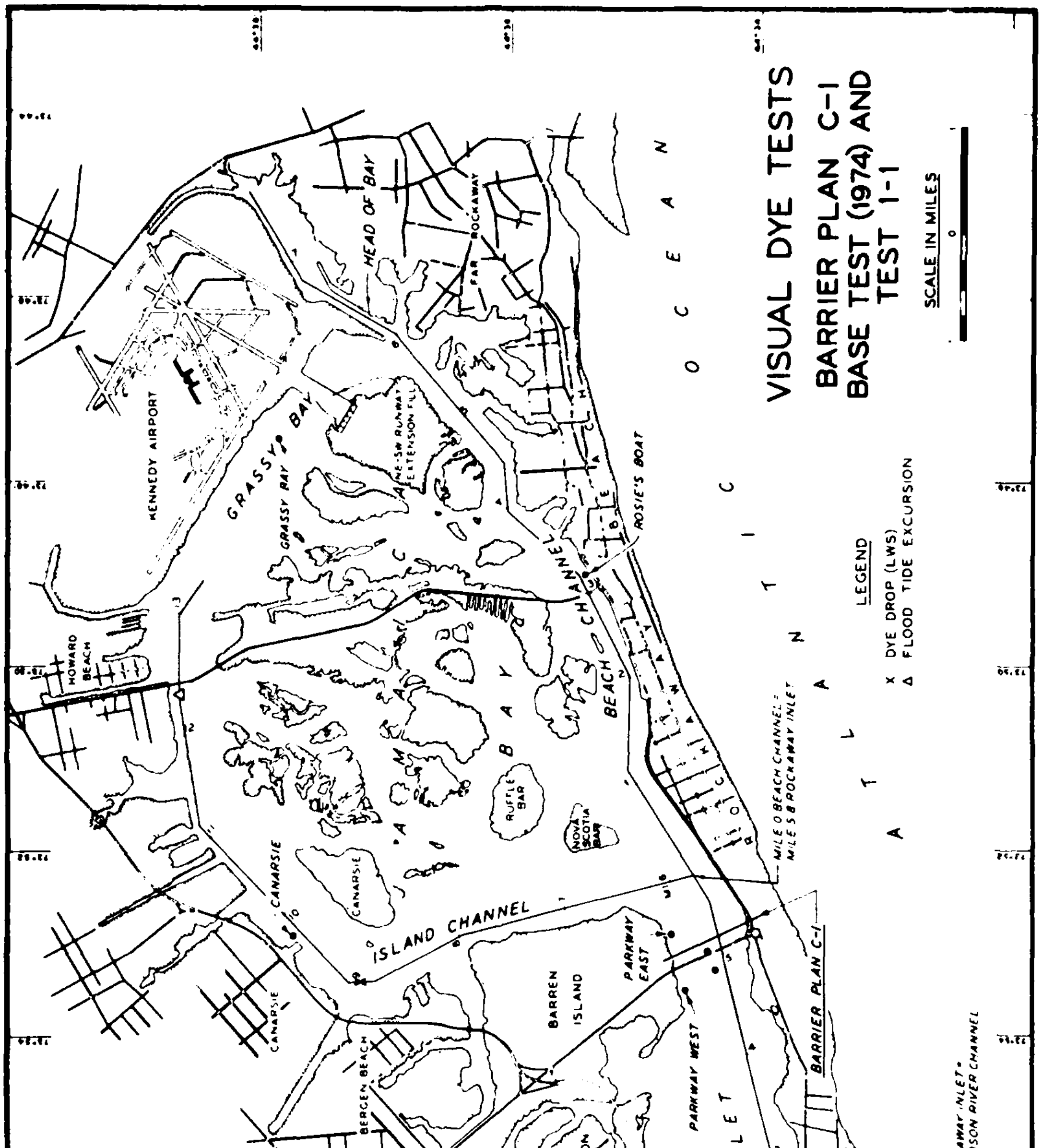

VISUAL DYE TESTS
BARRIER PLAN A
TEST 2
SCALE IN MILES
LEGEND
x DYE DROP (LWS)
Δ FLOOD TIDE EXCURSION
KENNEDY AIRPORT
GRASSY BAY
HEAD OF BAY
HOWARD BEACH
CANARSIE
ISLAND CHANNEL
BARREN ISLAND
PARKWAY EAST
PARKWAY WEST
BERGEN BEACH
GERRITSON
MANHATTAN BEACH
BROOKLYN
ROCKAWAY INLET
BEACH CHANNEL
ROSIE'S BOAT
RUFFLE BAR
LEVEE
BARRIER PLAN A
ROCKAWAY POINT
MILE 0 BEACH CHANNEL = MILE 5.8 ROCKAWAY INLET
MILE 0 ROCKAWAY INLET = MILE 16 HUDSON RIVER CHANNEL
ATLANTIC OCEAN
N

PLATE 87



VISUAL DYE TESTS
BARRIER PLAN A
TEST 3
SCALE IN MILES
LEGEND
X DYE DROP (LWS)
Δ FLOOD TIDE EXCURSION
KENNEDY AIRPORT
GRASSY BAY
HEAD OF BAY
FAR ROCKAWAY
ROSIE'S BOAT
BEACH CHANNEL
HOWARD BEACH
JAMAICA BAY
RUFFLE BAR
LEVEE
CANARSIE
ISLAND CHANNEL
BARREN ISLAND
PARKWAY EAST
PARKWAY WEST
BARRIER PLAN A
BERGEN BEACH
GERRITSON
MANHATTAN BEACH
BROOKLYN
ROCKAWAY INLET
ROCKAWAY POINT
ATLANTIC OCEAN
N

PLATE 88



VISUAL DYE TESTS
BARRIER PLAN C-1
BASE TEST (1974) AND
TEST 1-1
SCALE IN MILES
LEGEND
X DYE DROP (LWS)
Δ FLOOD TIDE EXCURSION
KENNEDY AIRPORT
GRASSY BAY
HOWARD BEACH
HEAD OF BAY
FAR ROCKAWAY
JAMAICA BAY
BEACH CHANNEL
ROSIE'S BOAT
RUFFLE BAR
NOVA SCOTIA BAR
CANARSIE
ISLAND CHANNEL
BARREN ISLAND
PARKWAY EAST
PARKWAY WEST
BARRIER PLAN C-1
BERGEN BEACH
GERRITSON
MANHATTAN BEACH
ROCKAWAY POINT
ROCKAWAY INLET
ATLANTIC OCEAN
BROOKLYN
N

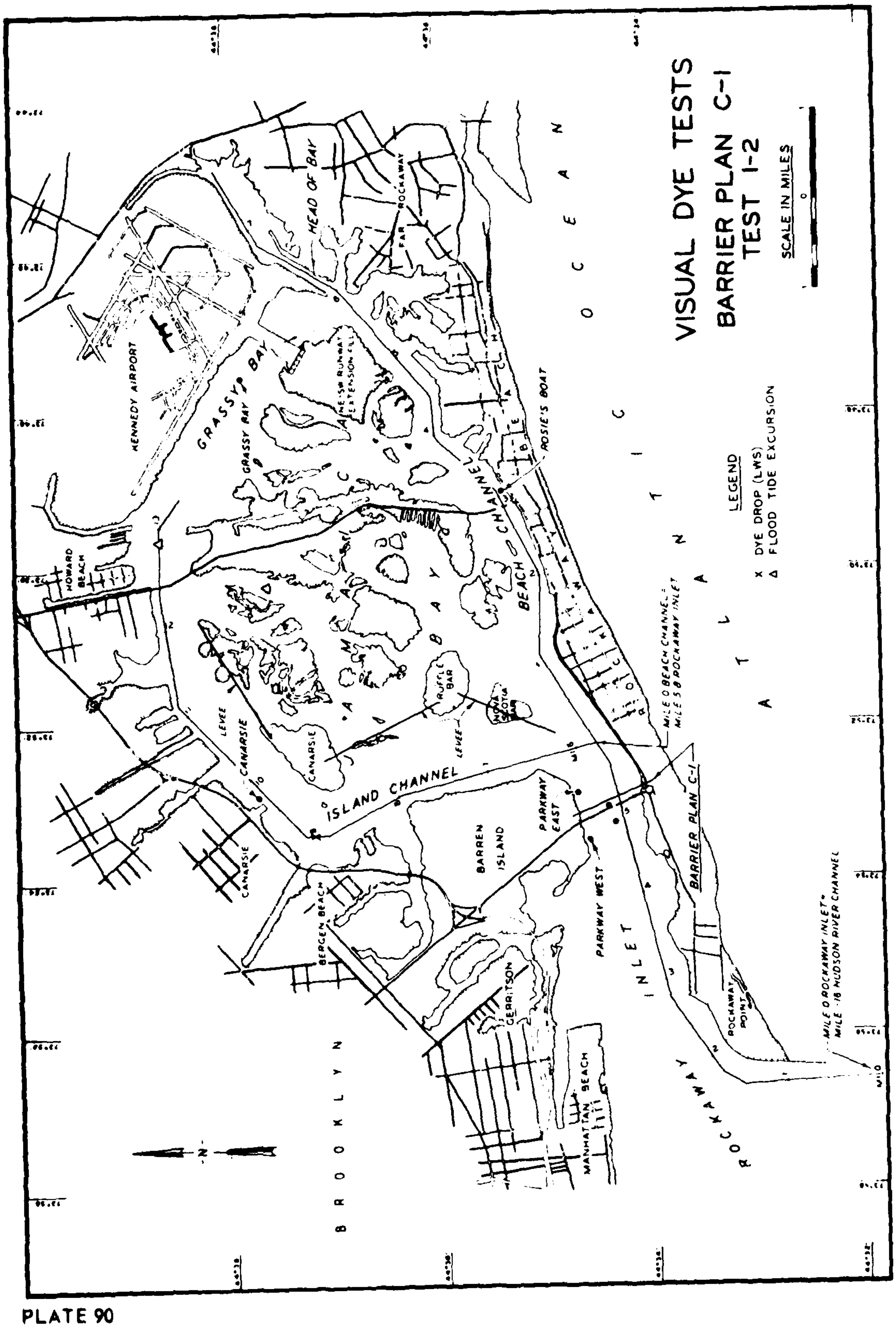
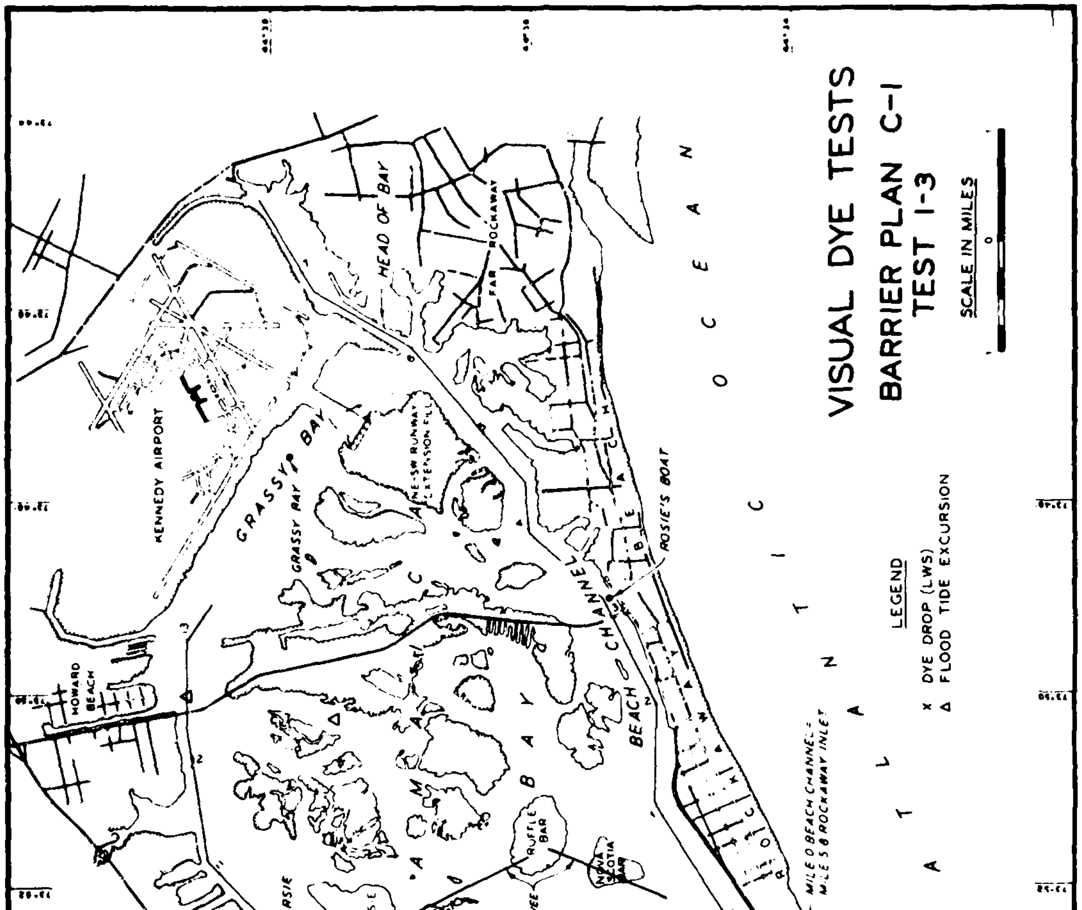

VISUAL DYE TESTS
BARRIER PLAN C-1
TEST 1-2
SCALE IN MILES
LEGEND
X DYE DROP (LWS)
Δ FLOOD TIDE EXCURSION
KENNEDY AIRPORT
GRASSY BAY
HEAD OF BAY
FAR ROCKAWAY
ROSIE'S BOAT
BEACH CHANNEL
HOWARD BEACH
RUFFLE BAR
NOVA SCOTIA BAR
CANARSIE
LEVEE
ISLAND CHANNEL
BARREN ISLAND
PARKWAY EAST
PARKWAY WEST
BERGEN BEACH
GERRITSON
MANHATTAN BEACH
BROOKLYN
ROCKAWAY INLET
ATLANTIC OCEAN
ROCKAWAY POINT
BARRIER PLAN C-1
MILE 0 BEACH CHANNEL = MILE 5.8 ROCKAWAY INLET
MILE 0 ROCKAWAY INLET = MILE 18 HUDSON RIVER CHANNEL
N

PLATE 90


VISUAL DYE TESTS
BARRIER PLAN C-1
TEST 1-3
SCALE IN MILES
LEGEND
X DYE DROP (LWS)
Δ FLOOD TIDE EXCURSION
A T L A N T I C
O C E A N
B R O O K L Y N
R O C K A W A Y
I N L E T
KENNEDY AIRPORT
GRASSY BAY
HEAD OF BAY
FAR ROCKAWAY
ROSIE'S BOAT
BEACH CHANNEL
J A M A I C A
B A Y
ISLAND CHANNEL
CANARSIE
RUFFLE BAR
NOVA SCOTIA BAR
LEVEE
BARREN ISLAND
PARKWAY EAST
PARKWAY WEST
BERGEN BEACH
GERRITSON
MANHATTAN BEACH
ROCKAWAY POINT
HOWARD BEACH
BARRIER PLAN C-1
MILE 0 BEACH CHANNEL = MILE 5.8 ROCKAWAY INLET
MILE 0 ROCKAWAY INLET = MILE 16 HUDSON RIVER CHANNEL
-N-

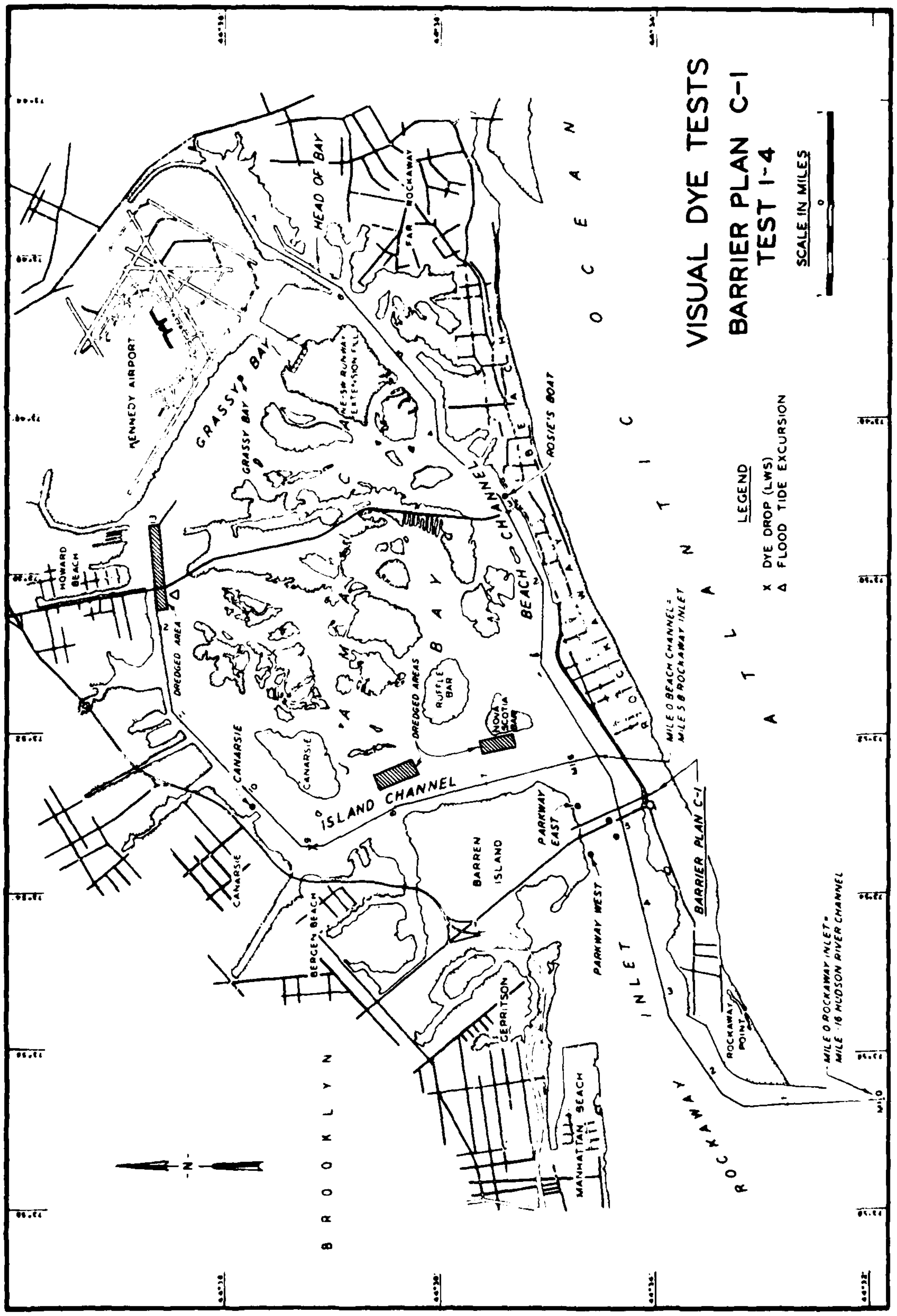
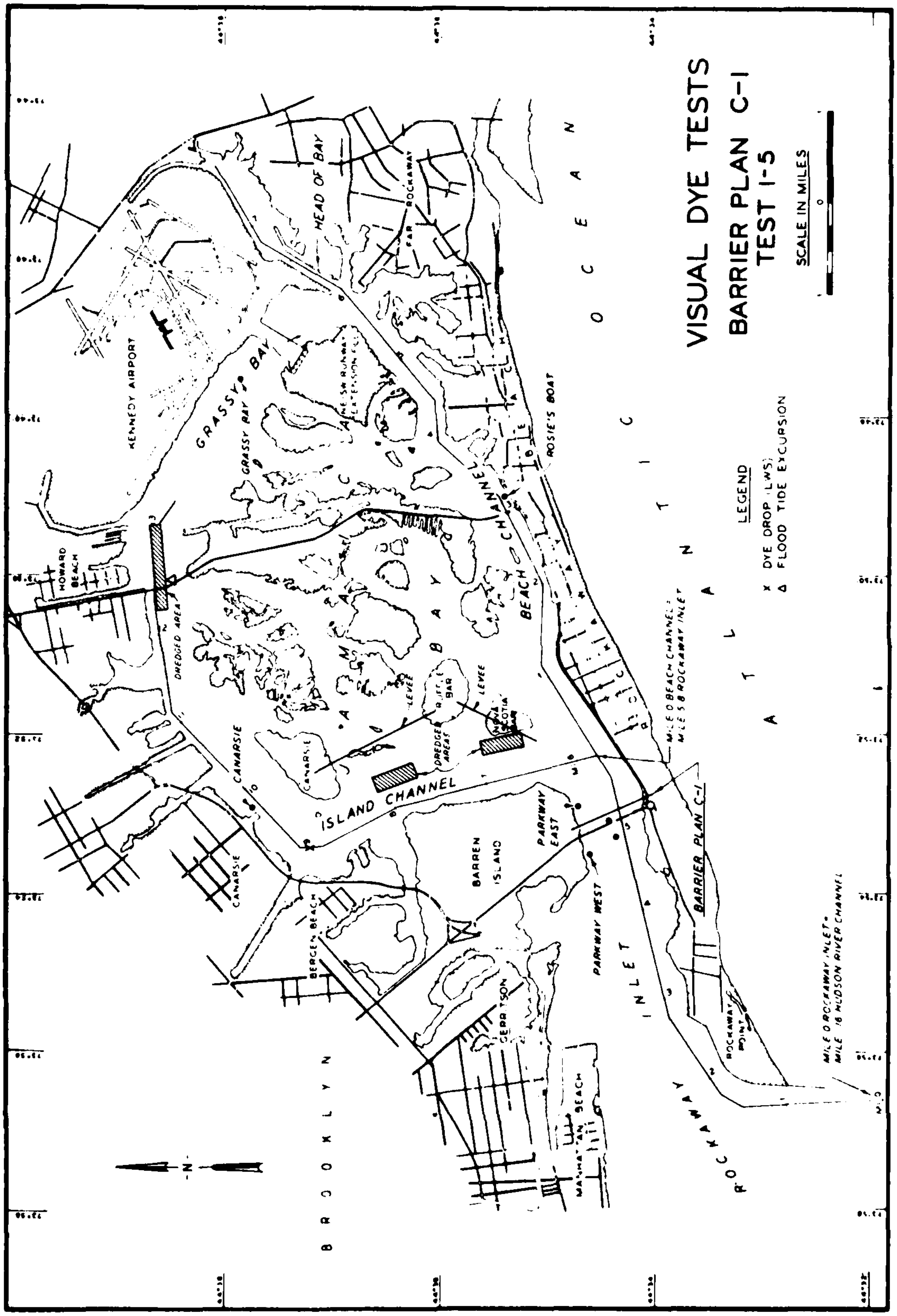
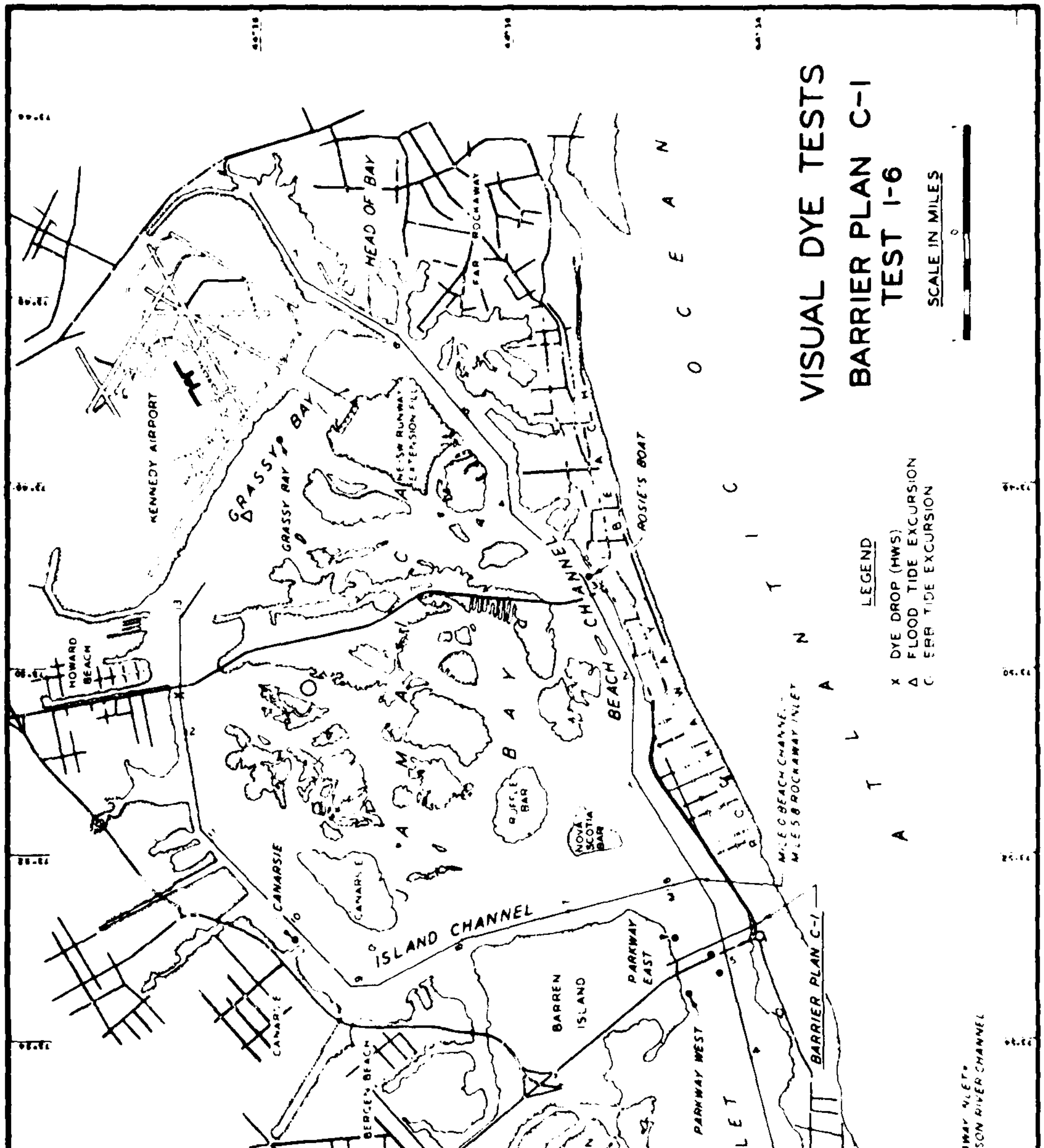

VISUAL DYE TESTS
BARRIER PLAN C-1
TEST 1-4
SCALE IN MILES
LEGEND
X DYE DROP (LWS)
Δ FLOOD TIDE EXCURSION
ATLANTIC OCEAN
BROOKLYN
ROCKAWAY INLET
JAMAICA BAY
KENNEDY AIRPORT
GRASSY BAY
HEAD OF BAY
FAR ROCKAWAY
ROCKAWAY BEACH
BEACH CHANNEL
ROSIE'S BOAT
HOWARD BEACH
DREDGED AREA
DREDGED AREAS
RUFFLE BAR
NOVA SCOTIA BAR
CANARSIE
ISLAND CHANNEL
BARREN ISLAND
PARKWAY EAST
PARKWAY WEST
BARRIER PLAN C-1
MILE 0 BEACH CHANNEL = MILE 5.8 ROCKAWAY INLET
MILE 0 ROCKAWAY INLET = MILE 16 HUDSON RIVER CHANNEL
ROCKAWAY POINT
BERGEN BEACH
GERRITSON
MANHATTAN BEACH
N

PLATE 92



VISUAL DYE TESTS
BARRIER PLAN C-1
TEST I-5
SCALE IN MILES
LEGEND
X DYE DROP (LWS)
Δ FLOOD TIDE EXCURSION
KENNEDY AIRPORT
GRASSY BAY
HEAD OF BAY
HOWARD BEACH
DREDGED AREA
CANARSIE
ISLAND CHANNEL
BEACH CHANNEL
BARREN ISLAND
PARKWAY EAST
PARKWAY WEST
BERGEN BEACH
GERRITSON
ROCKAWAY INLET
ROCKAWAY POINT
BARRIER PLAN C-1
ROSIE'S BOAT
RUFFLE BAR
LEVEE
NOVA SCOTIA BAR
DREDGED AREAS
BROOKLYN
ATLANTIC OCEAN
JAMAICA BAY
MILE 0 ROCKAWAY INLET
MILE 16 HUDSON RIVER CHANNEL
MILE 0 BEACH CHANNEL
MILE 5.8 ROCKAWAY INLET

PLATE 93



VISUAL DYE TESTS
BARRIER PLAN C-1
TEST 1-6
SCALE IN MILES
LEGEND
X DYE DROP (HWS)
Δ FLOOD TIDE EXCURSION
C EBB TIDE EXCURSION
KENNEDY AIRPORT
GRASSY BAY
HEAD OF BAY
FAR ROCKAWAY
ROSIE'S BOAT
HOWARD BEACH
BEACH CHANNEL
ISLAND CHANNEL
CANARSIE
BARREN ISLAND
PARKWAY EAST
PARKWAY WEST
RUFFLE BAR
NOVA SCOTIA BAR
BARRIER PLAN C-1
ROCKAWAY INLET
BROOKLYN
MANHATTAN BEACH
GERRITSON
BERGEN BEACH
ROCKAWAY POINT
ATLANTIC OCEAN
JAMAICA BAY
N

PLATE 94

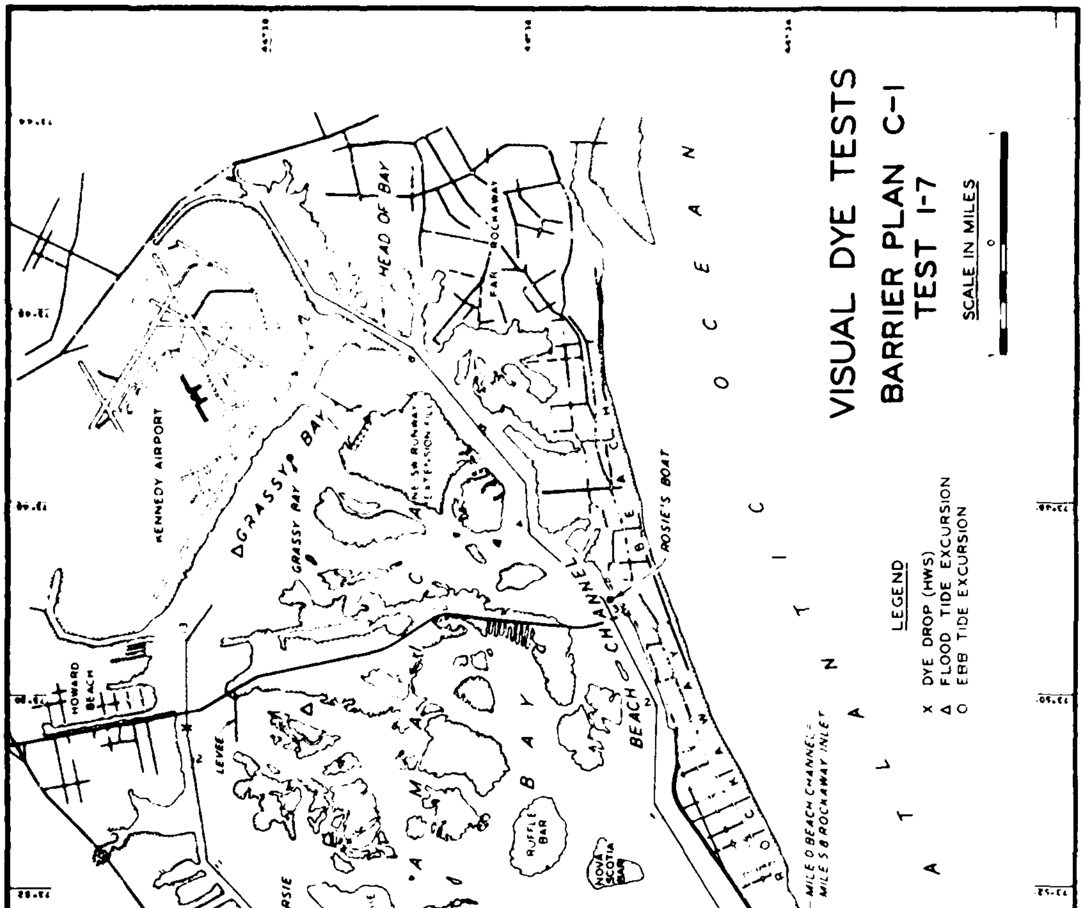

VISUAL DYE TESTS
BARRIER PLAN C-1
TEST 1-7
SCALE IN MILES
LEGEND
X DYE DROP (HWS)
Δ FLOOD TIDE EXCURSION
O EBB TIDE EXCURSION
KENNEDY AIRPORT
GRASSY BAY
HEAD OF BAY
FAR ROCKAWAY
HOWARD BEACH
LEVEE
JAMAICA BAY
BEACH CHANNEL
ROSIE'S BOAT
RUFFLE BAR
NOVA SCOTIA BAR
CANARSIE
ISLAND CHANNEL
BARREN ISLAND
PARKWAY EAST
PARKWAY WEST
BARRIER PLAN C-1
BERGEN BEACH
GERRITSON
MANHATTAN BEACH
ROCKAWAY POINT
ROCKAWAY INLET
BROOKLYN
ATLANTIC OCEAN
MILE 0 BEACH CHANNEL = MILE 5.8 ROCKAWAY INLET
MILE 0 ROCKAWAY INLET = MILE 16 HUDSON RIVER CHANNEL
N

PLATE 95

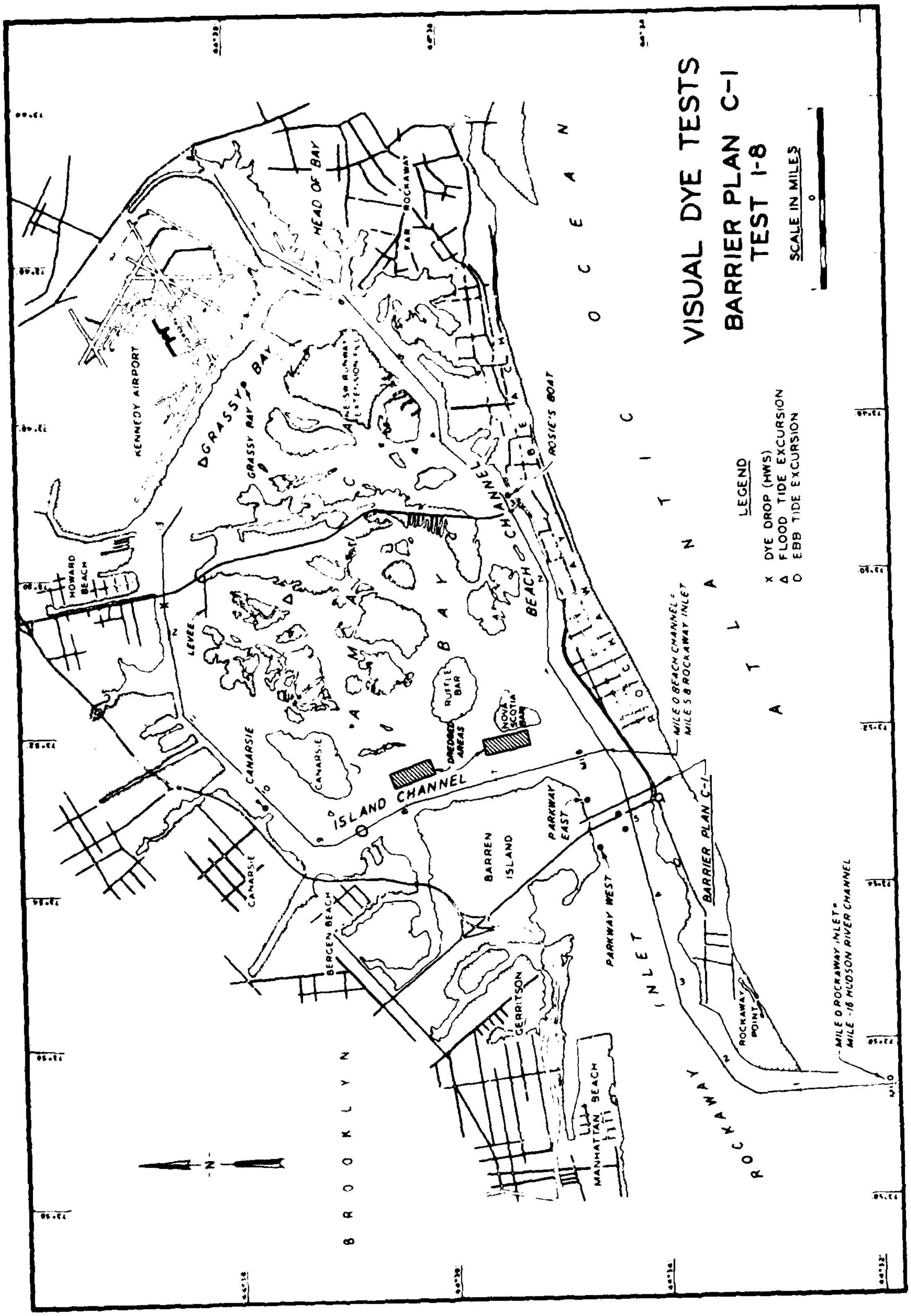
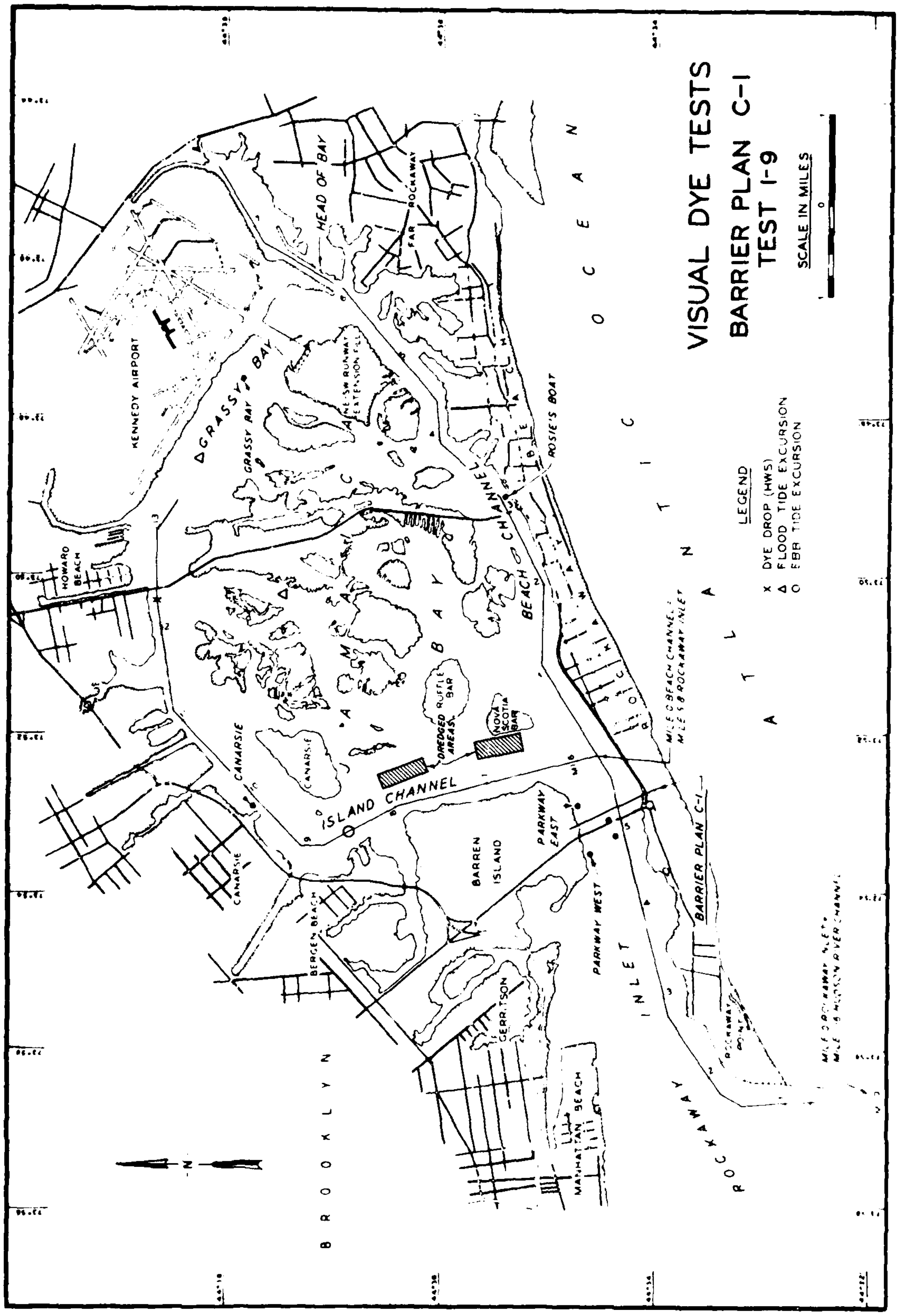
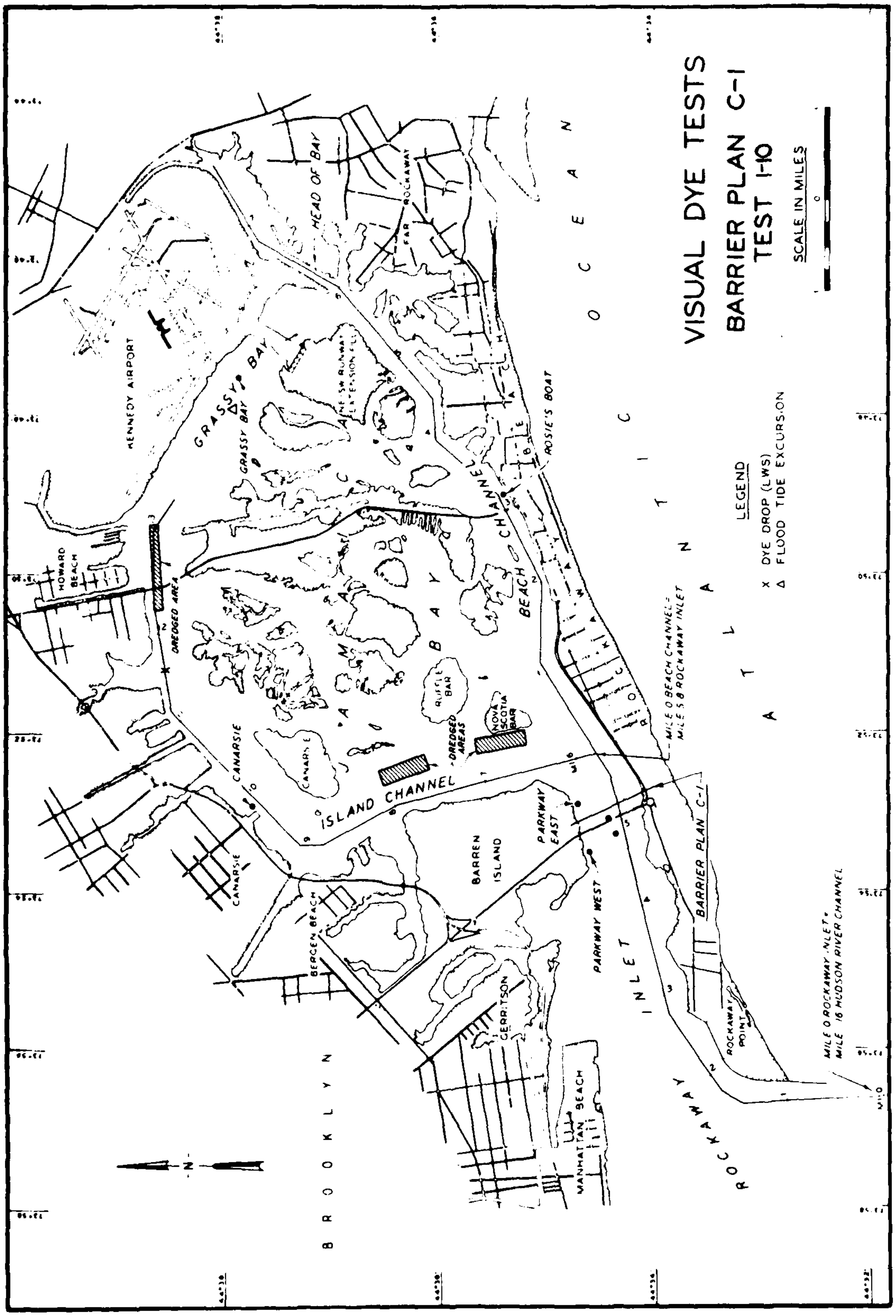

VISUAL DYE TESTS
BARRIER PLAN C-1
TEST 1-8
SCALE IN MILES
LEGEND
X DYE DROP (HWS)
Δ FLOOD TIDE EXCURSION
O EBB TIDE EXCURSION
KENNEDY AIRPORT
GRASSY BAY
HEAD OF BAY
FAR ROCKAWAY
HOWARD BEACH
LEVEE
CANARSIE
ISLAND CHANNEL
DREDGED AREAS
RUFFLE BAR
NOVA SCOTIA BAR
BEACH CHANNEL
ROSIE'S BOAT
BARREN ISLAND
PARKWAY EAST
PARKWAY WEST
BERGEN BEACH
GERRITSON
MANHATTAN BEACH
ROCKAWAY POINT
BARRIER PLAN C-1
MILE 0 BEACH CHANNEL = MILE 5.8 ROCKAWAY INLET
MILE 0 ROCKAWAY INLET = MILE -18 HUDSON RIVER CHANNEL
ROCKAWAY INLET
BROOKLYN
ATLANTIC OCEAN
N

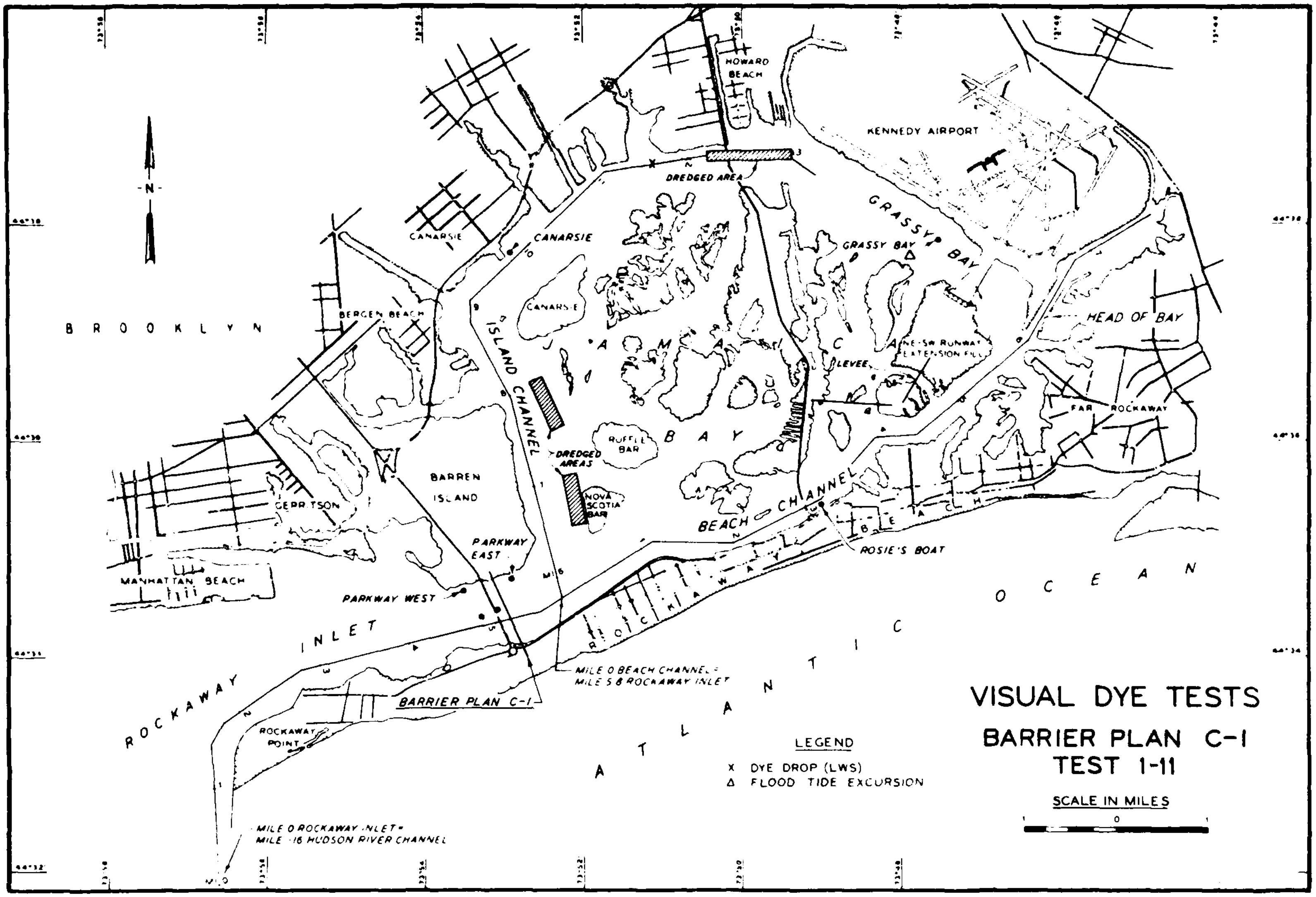
PLATE 96


VISUAL DYE TESTS
BARRIER PLAN C-1
TEST 1-9
SCALE IN MILES
LEGEND
X DYE DROP (HWS)
Δ FLOOD TIDE EXCURSION
O EBB TIDE EXCURSION
KENNEDY AIRPORT
GRASSY BAY
HEAD OF BAY
FAR ROCKAWAY
ATLANTIC OCEAN
JAMAICA BAY
BEACH CHANNEL
ISLAND CHANNEL
ROSIE'S BOAT
HOWARD BEACH
CANARSIE
RUFFLE BAR
NOVA SCOTIA BAR
DREDGED AREAS
BARREN ISLAND
PARKWAY EAST
PARKWAY WEST
BERGEN BEACH
GERRITSON
MANHATTAN BEACH
BROOKLYN
ROCKAWAY INLET
ROCKAWAY POINT
BARRIER PLAN C-1



VISUAL DYE TESTS
BARRIER PLAN C-1
TEST 1-10
SCALE IN MILES
LEGEND
X DYE DROP (LWS)
Δ FLOOD TIDE EXCURSION
KENNEDY AIRPORT
GRASSY BAY
HEAD OF BAY
FAR ROCKAWAY
HOWARD BEACH
DREDGED AREA
DREDGED AREAS
CANARSIE
BARREN ISLAND
PARKWAY EAST
PARKWAY WEST
ISLAND CHANNEL
BEACH CHANNEL
ROSIE'S BOAT
RUFFLE BAR
NOVA SCOTIA BAR
BERGEN BEACH
GERRITSON
MANHATTAN BEACH
BROOKLYN
ROCKAWAY INLET
ROCKAWAY POINT
BARRIER PLAN C-1
ATLANTIC OCEAN
MILE 0 BEACH CHANNEL = MILE 5.8 ROCKAWAY INLET
MILE 0 ROCKAWAY INLET = MILE 16 HUDSON RIVER CHANNEL

PLATE 98


VISUAL DYE TESTS
BARRIER PLAN C-1
TEST 1-11
SCALE IN MILES
LEGEND
X DYE DROP (LWS)
Δ FLOOD TIDE EXCURSION
KENNEDY AIRPORT
HOWARD BEACH
DREDGED AREA
GRASSY BAY
HEAD OF BAY
FAR ROCKAWAY
NE-SW RUNWAY EXTENSION FILL
LEVEE
JAMAICA BAY
CANARSIE
BERGEN BEACH
BROOKLYN
ISLAND CHANNEL
RUFFLE BAR
DREDGED AREAS
NOVA SCOTIA BAR
BARREN ISLAND
GERRITSON
MANHATTAN BEACH
PARKWAY EAST
PARKWAY WEST
BEACH CHANNEL
ROSIE'S BOAT
ROCKAWAY
ATLANTIC OCEAN
ROCKAWAY INLET
MILE 0 BEACH CHANNEL = MILE 5.8 ROCKAWAY INLET
BARRIER PLAN C-1
ROCKAWAY POINT
MILE 0 ROCKAWAY INLET = MILE -16 HUDSON RIVER CHANNEL
N

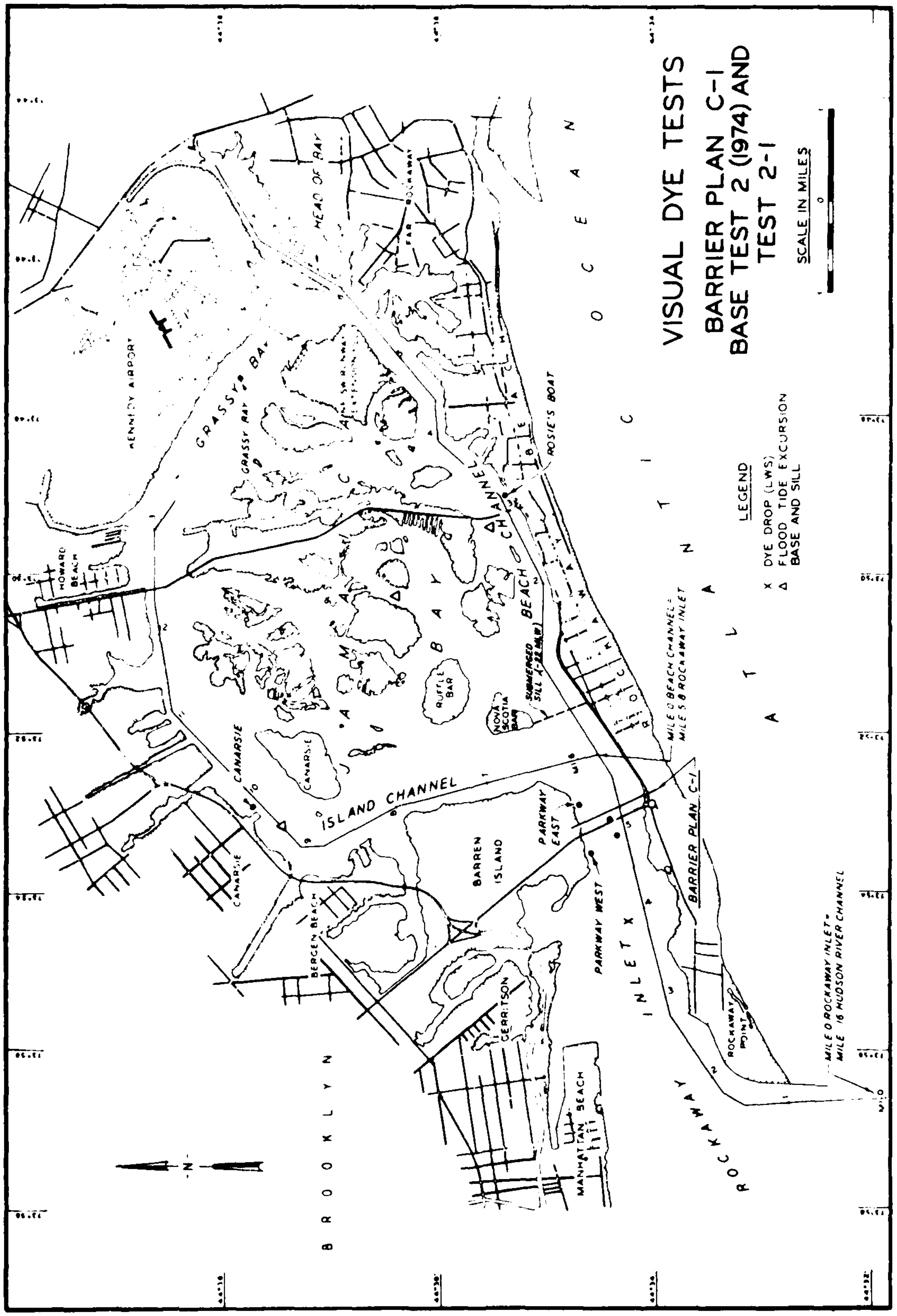

VISUAL DYE TESTS
BARRIER PLAN C-1
BASE TEST 2 (1974) AND
TEST 2-1
SCALE IN MILES
LEGEND
X DYE DROP (LWS)
Δ FLOOD TIDE EXCURSION
BASE AND SILL
ATLANTIC OCEAN
BROOKLYN
ROCKAWAY INLET
JAMAICA BAY
KENNEDY AIRPORT
GRASSY BAY
HEAD OF BAY
FAR ROCKAWAY
ROSIE'S BOAT
BEACH CHANNEL
ISLAND CHANNEL
HOWARD BEACH
CANARSIE
RUFFLE BAR
NOVA SCOTIA BAR
SUBMERGED SILL
BARREN ISLAND
PARKWAY EAST
PARKWAY WEST
BARRIER PLAN C-1
BERGEN BEACH
GERRITSON
MANHATTAN BEACH
ROCKAWAY POINT
MILE 0 BEACH CHANNEL = MILE 5.8 ROCKAWAY INLET
MILE 0 ROCKAWAY INLET = MILE 16 HUDSON RIVER CHANNEL

PLATE 100

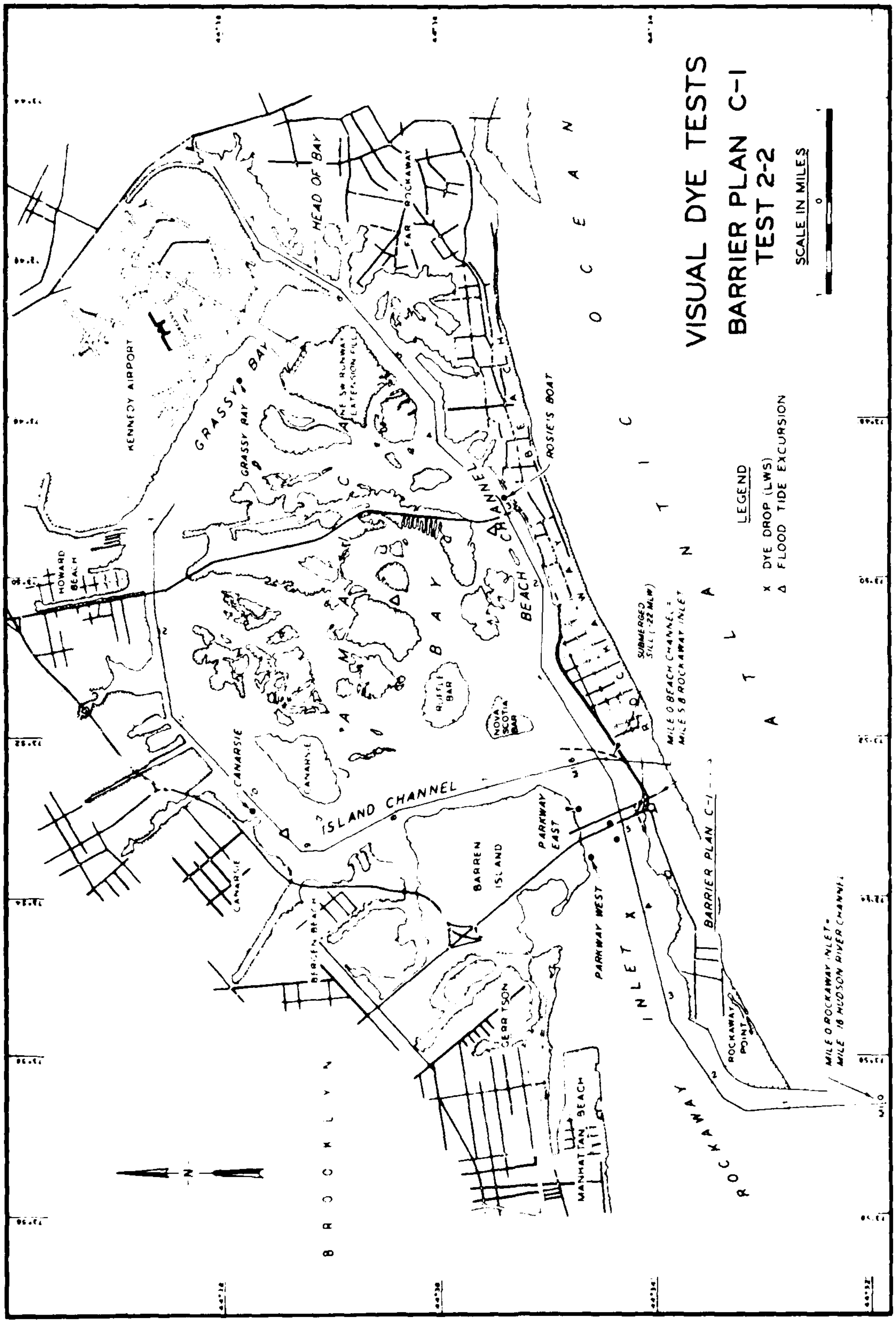
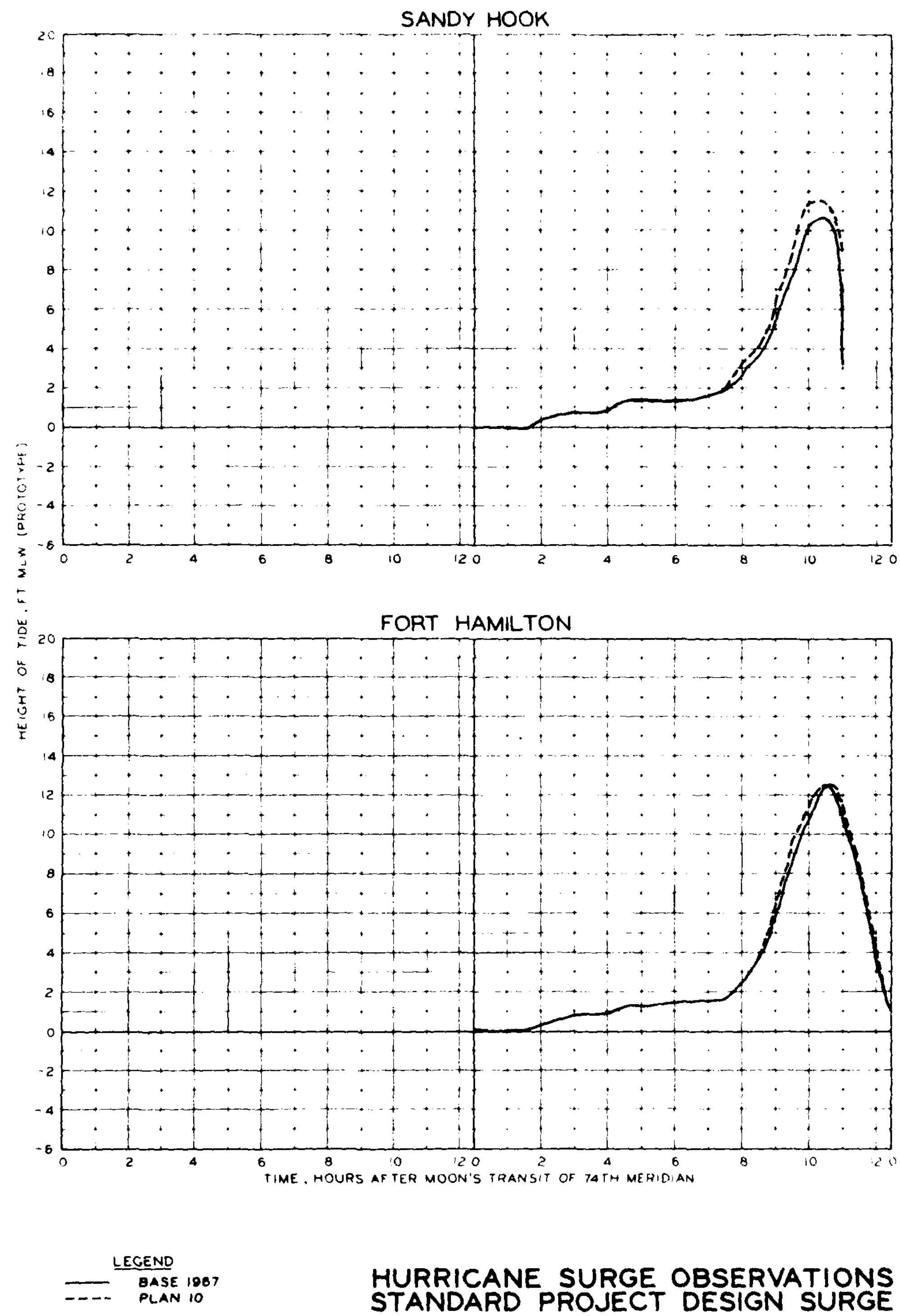
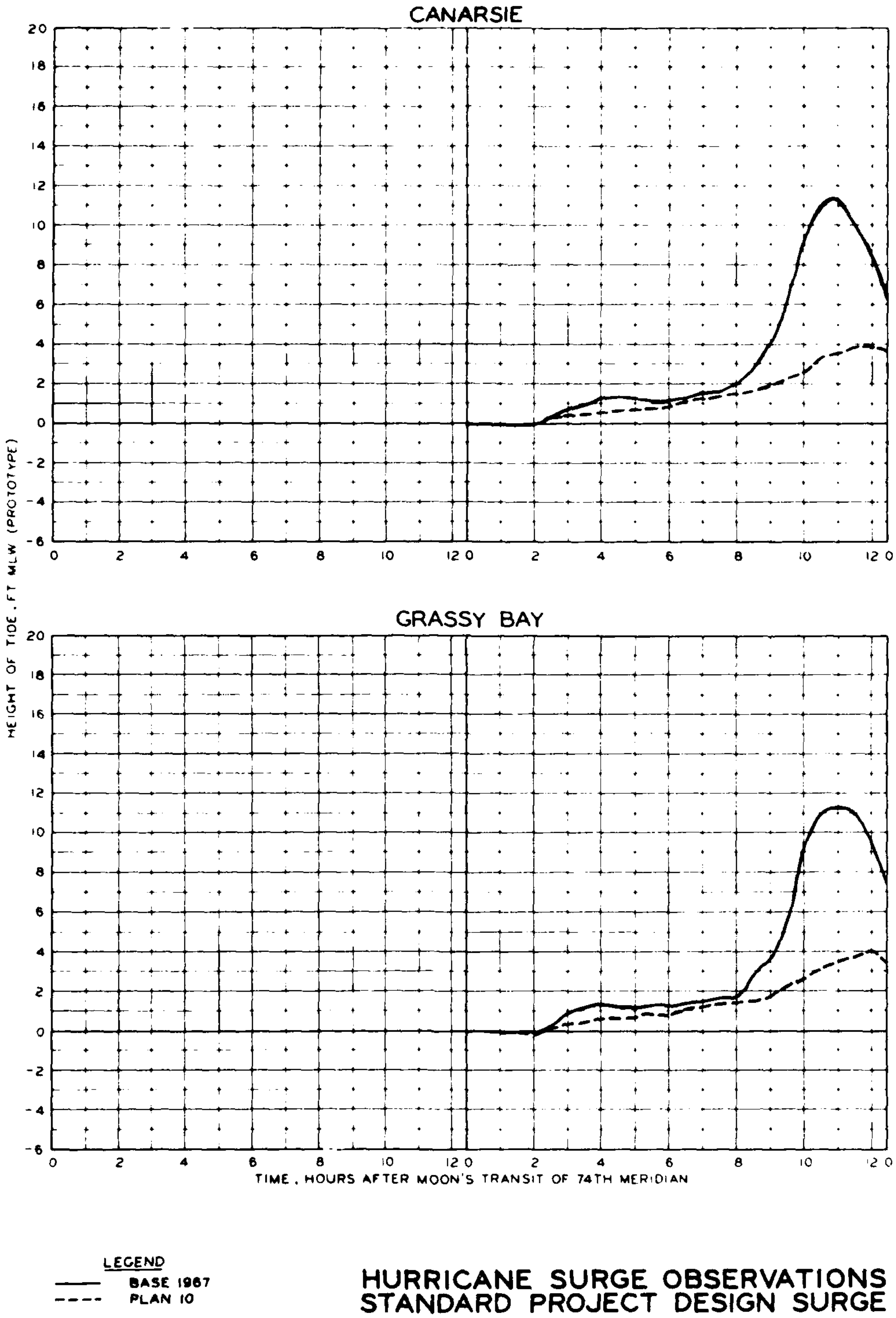

VISUAL DYE TESTS
BARRIER PLAN C-1
TEST 2-2
SCALE IN MILES
LEGEND
x DYE DROP (LWS)
Δ FLOOD TIDE EXCURSION
KENNEDY AIRPORT
GRASSY BAY
HEAD OF BAY
FAR ROCKAWAY
ROSIE'S BOAT
HOWARD BEACH
BEACH CHANNEL
ISLAND CHANNEL
CANARSIE
BARREN ISLAND
PARKWAY EAST
PARKWAY WEST
BERGEN BEACH
GERRITSON
MANHATTAN BEACH
RULEF BAR
NOVA SCOTIA BAR
SUBMERGED SILL (-22 MLW)
MILE 0 BEACH CHANNEL = MILE 5.8 ROCKAWAY INLET
BARRIER PLAN C-1
ROCKAWAY POINT
MILE 0 ROCKAWAY INLET = MILE 18 HUDSON RIVER CHANNEL
ROCKAWAY INLET
BROOKLYN
ATLANTIC OCEAN
JAMAICA BAY
N

PLATE 101



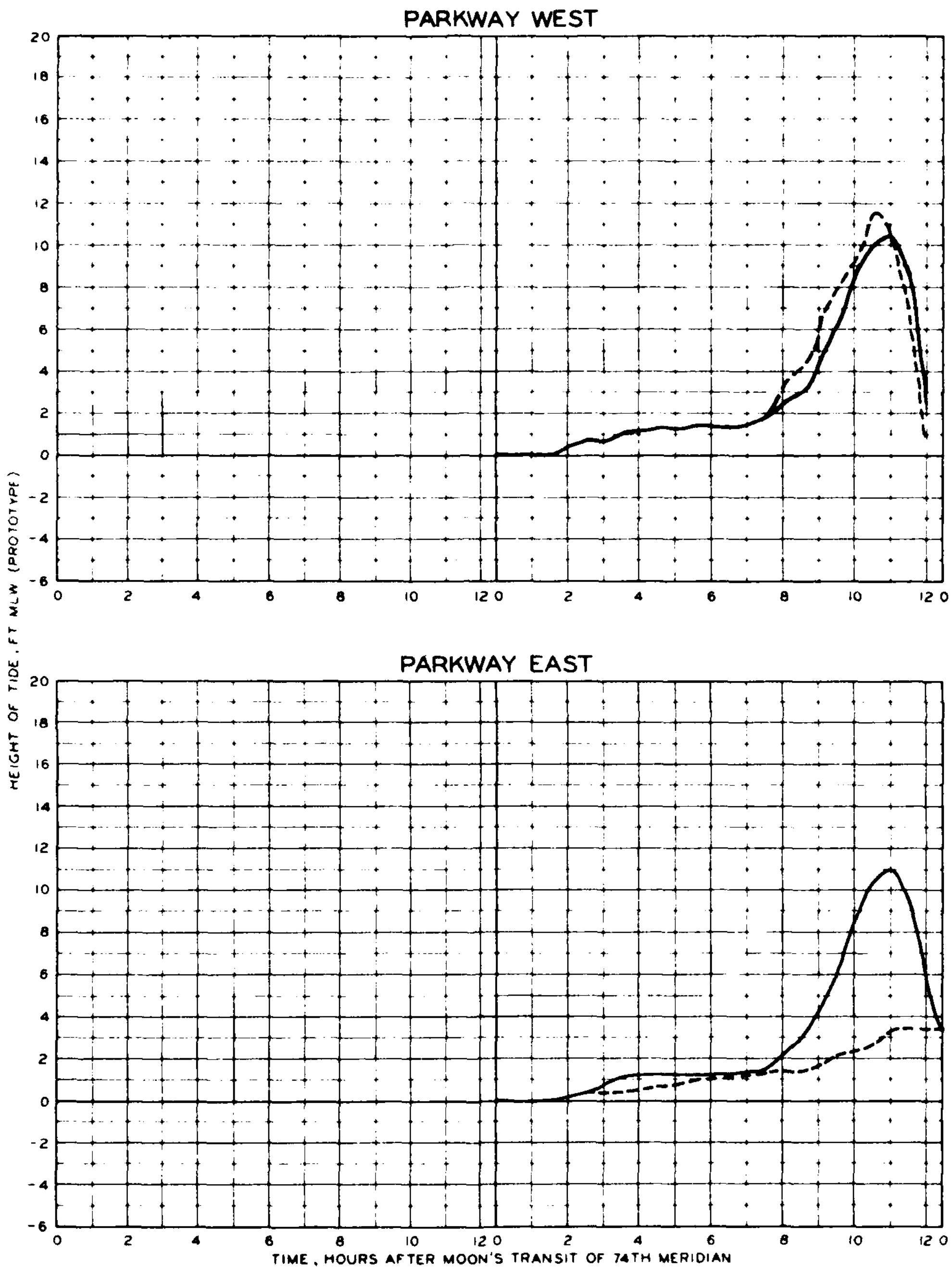
HURRICANE SURGE OBSERVATIONS
STANDARD PROJECT DESIGN SURGE
PLAN 10

SANDY HOOK AND FORT HAMILTON



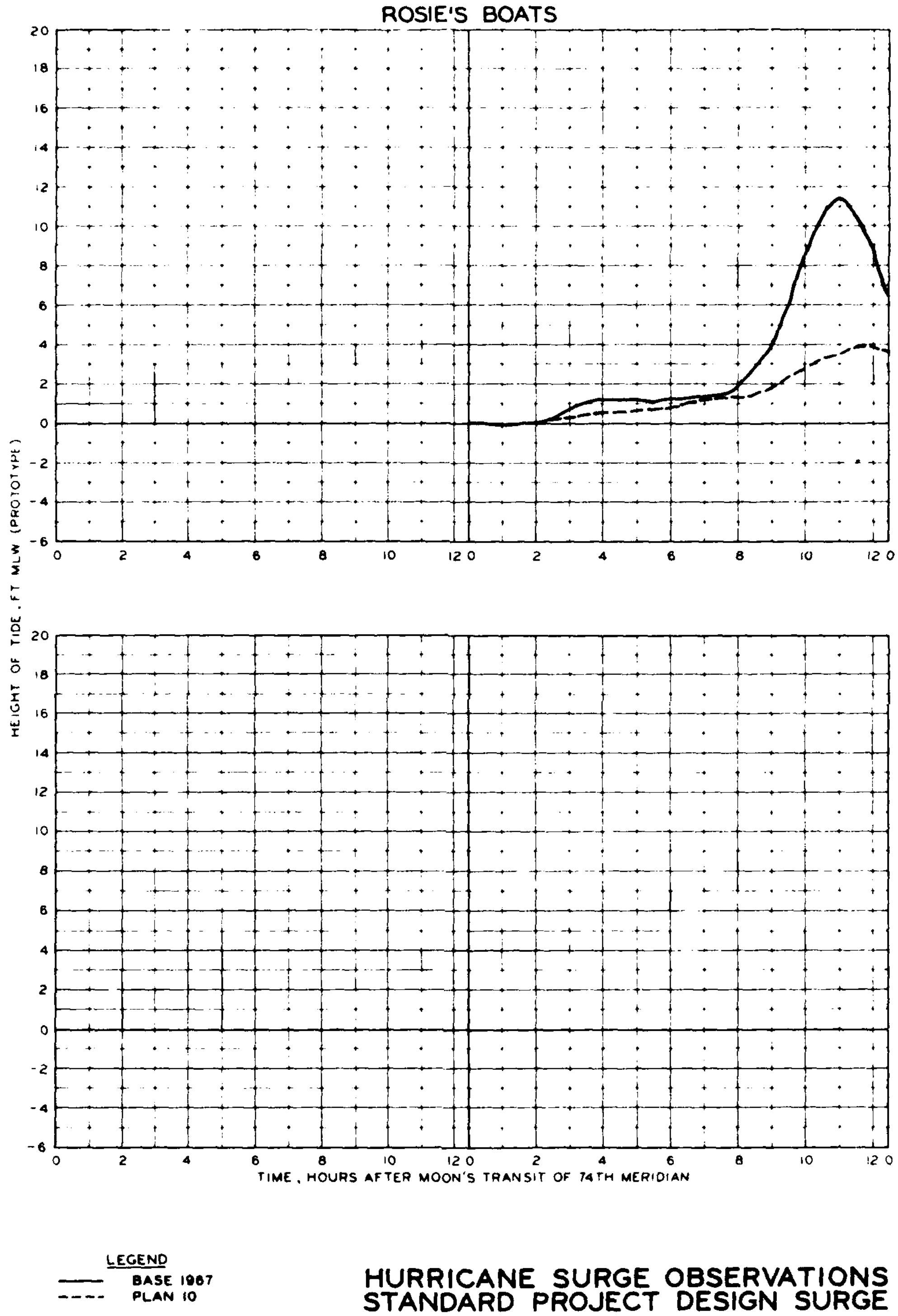
HURRICANE SURGE OBSERVATIONS
STANDARD PROJECT DESIGN SURGE
PLAN 10

CANARSIE AND GRASSY BAY



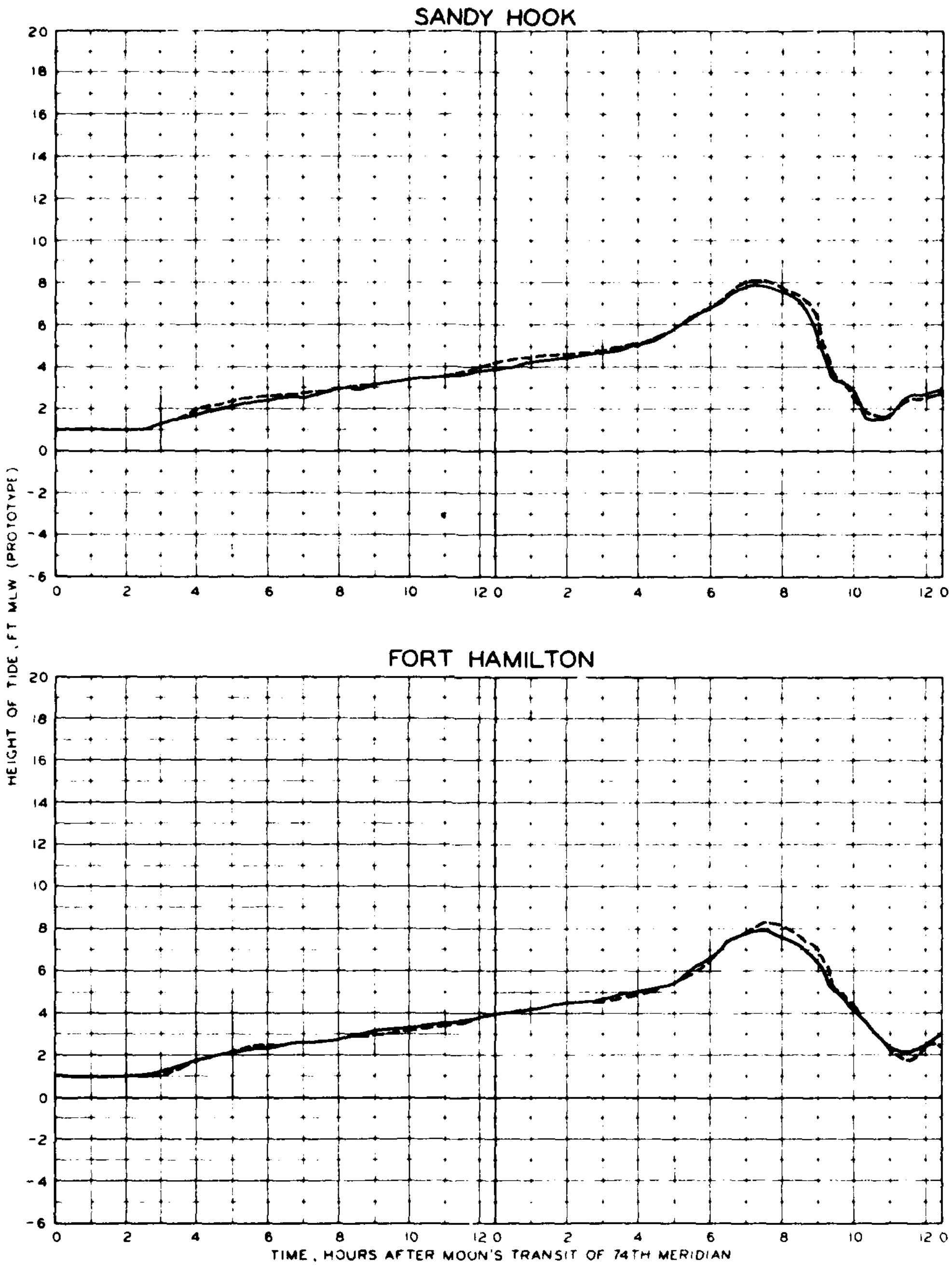
HURRICANE SURGE OBSERVATIONS
STANDARD PROJECT DESIGN SURGE
PLAN 10

PARKWAY WEST AND PARKWAY EAST



HURRICANE SURGE OBSERVATIONS
STANDARD PROJECT DESIGN SURGE
PLAN 10

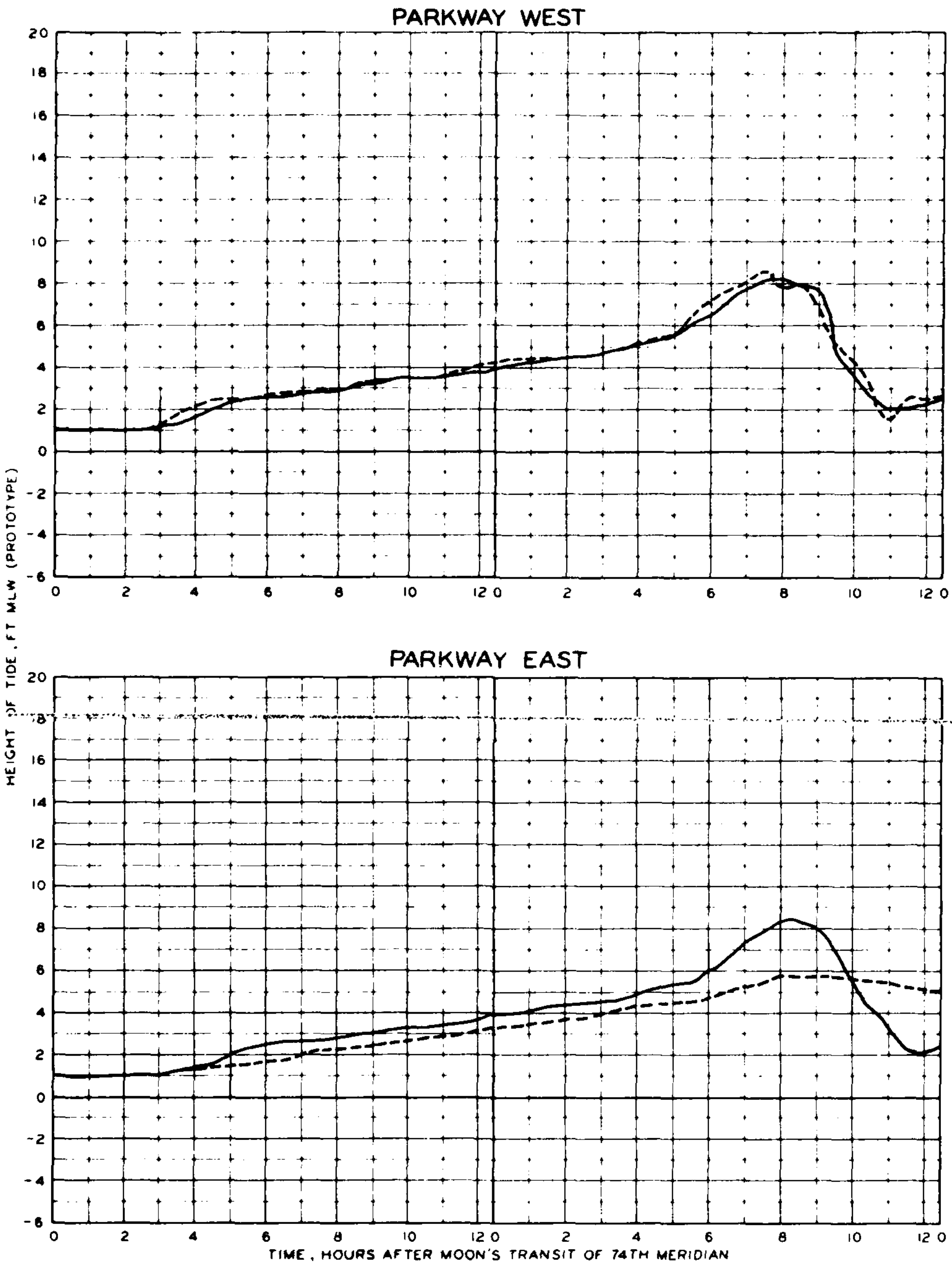
ROSIE'S BOATS



LEGEND
—— BASE 1987
- - - - PLAN 10

HURRICANE SURGE OBSERVATIONS
NOVEMBER 1950 SURGE
PLAN 10

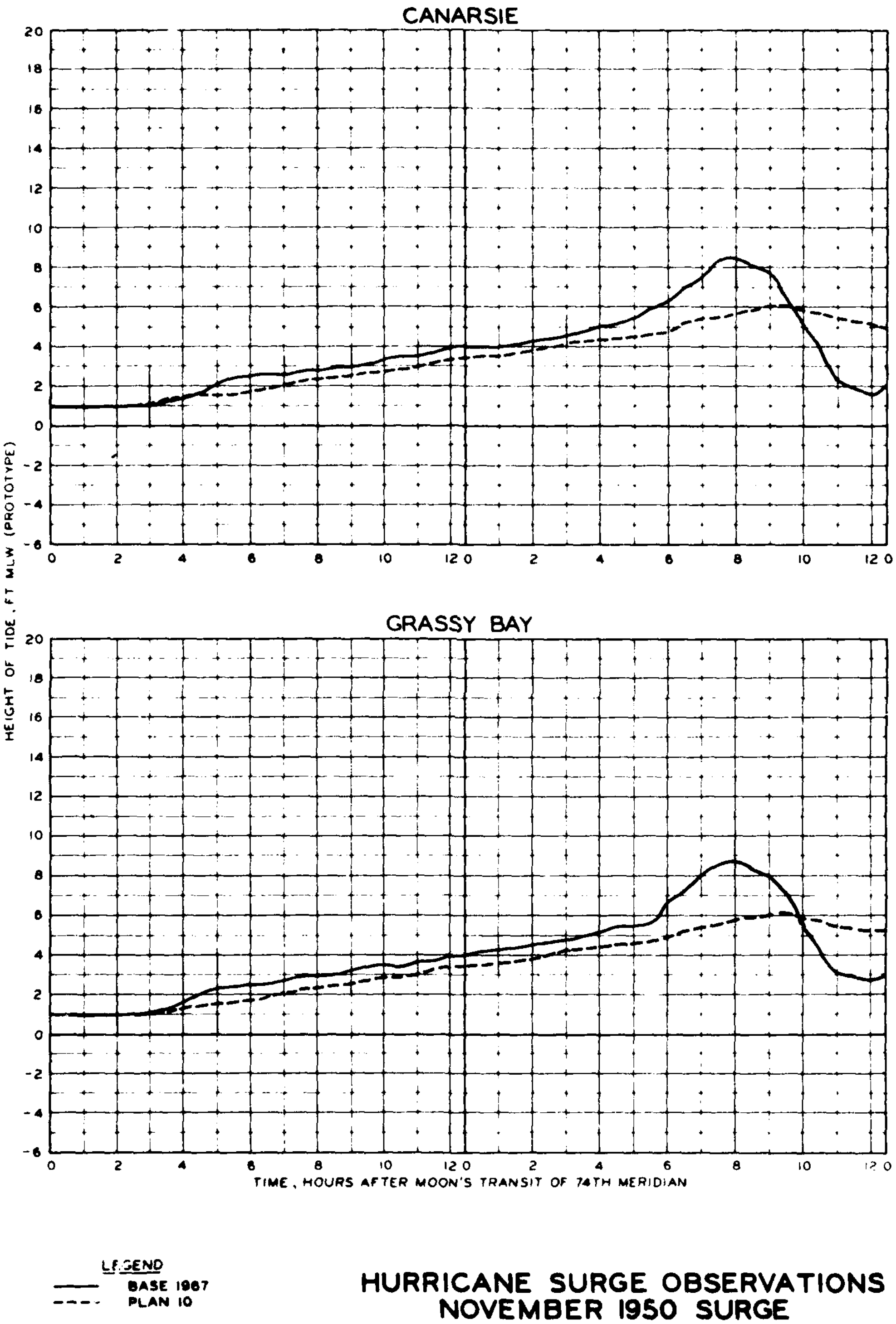
SANDY HOOK AND FORT HAMILTON



LEGEND
—— BASE 1967
---- PLAN 10

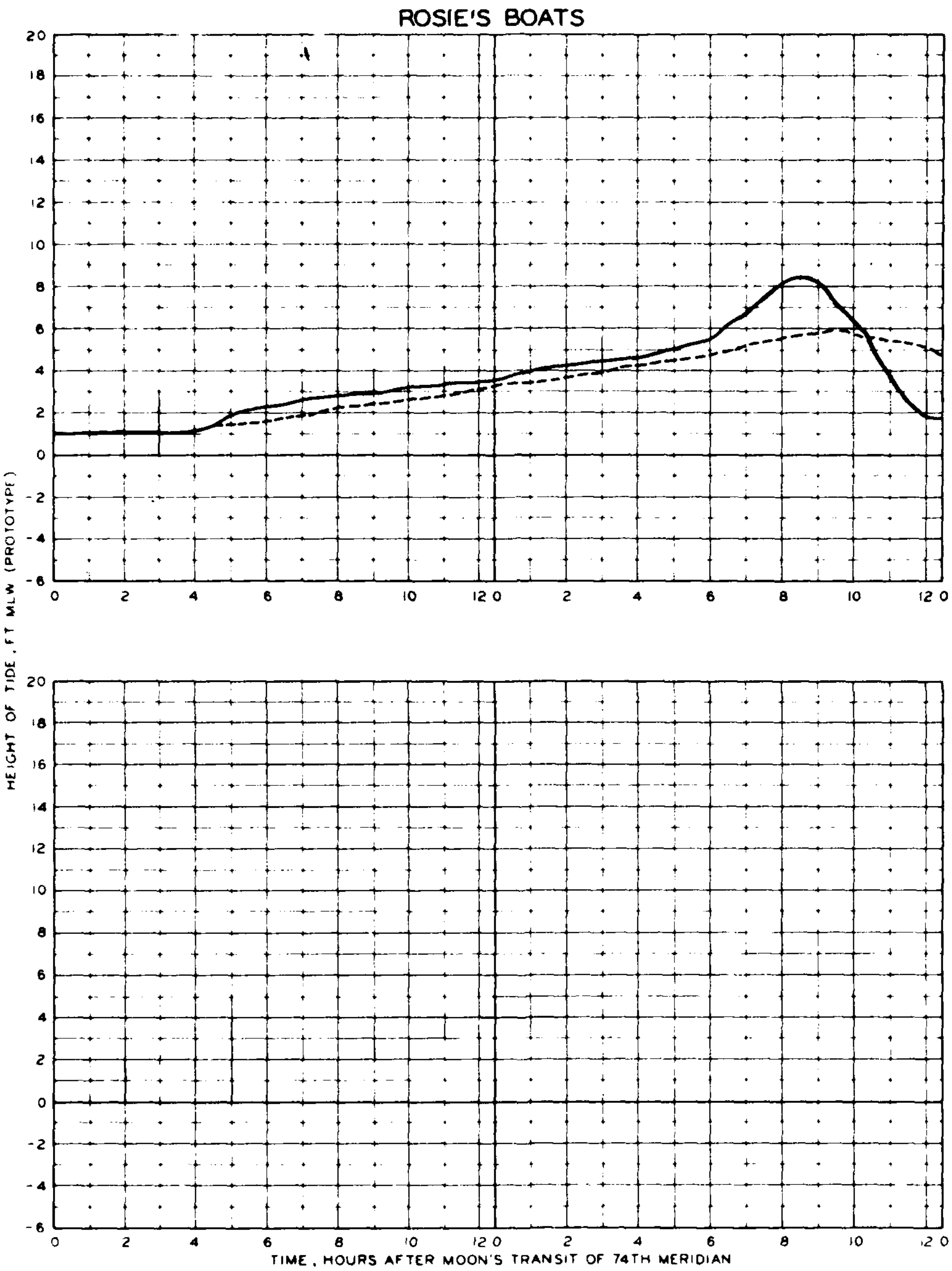
HURRICANE SURGE OBSERVATIONS
NOVEMBER 1950 SURGE
PLAN 10

PARKWAY WEST AND PARKWAY EAST



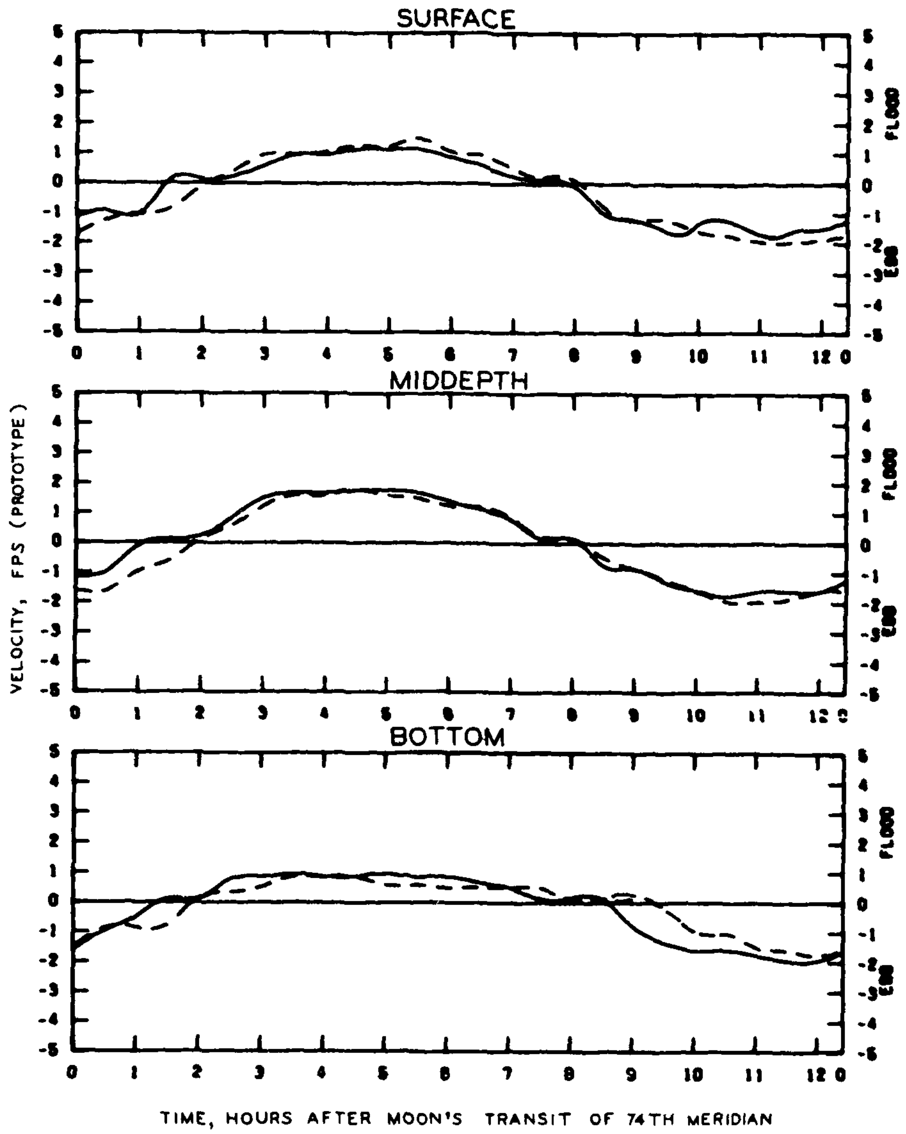
HURRICANE SURGE OBSERVATIONS
NOVEMBER 1950 SURGE
PLAN 10

CANARSIE AND GRASSY BAY



HURRICANE SURGE OBSERVATIONS
NOVEMBER 1950 SURGE
PLAN 10

ROSIE'S BOATS



TEST CONDITIONS

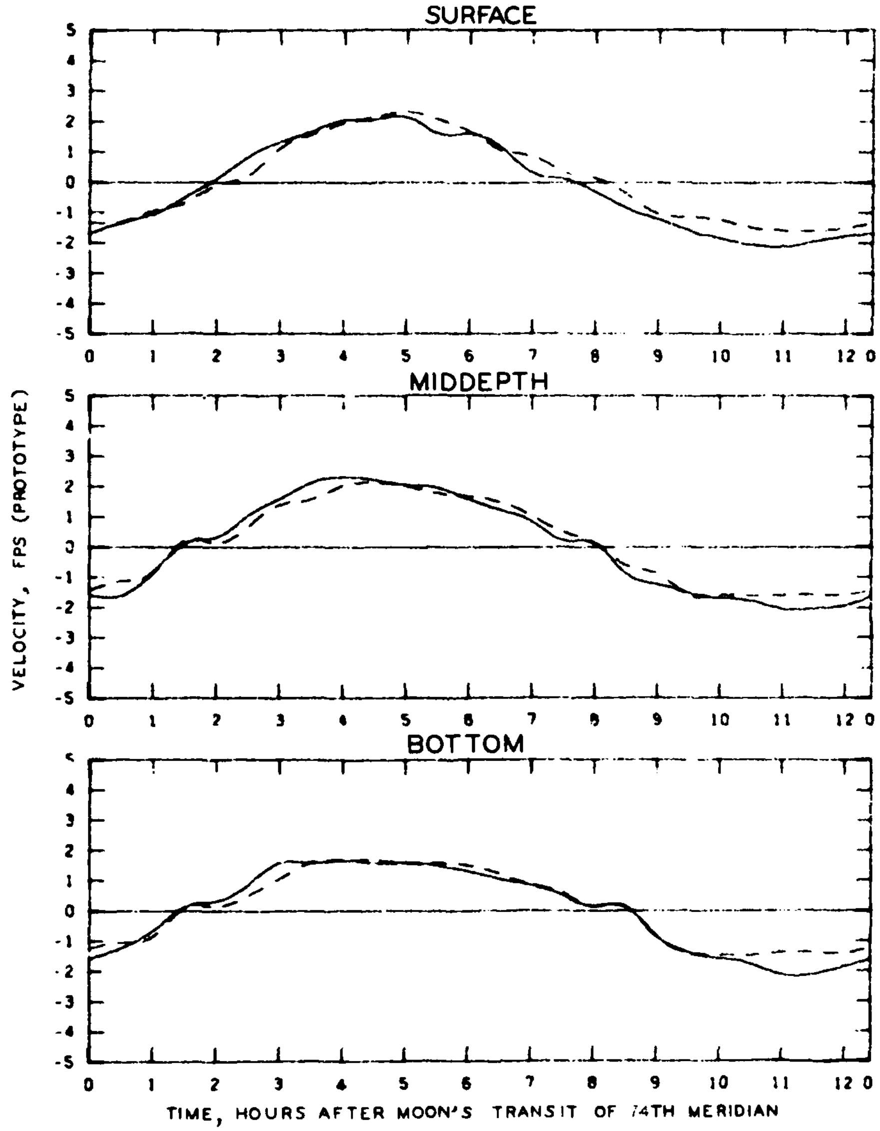
TIDAL RANGE AT SANDY HOOK	4 7 FT
OCEAN SALINITY (TOTAL SALT)	30 0 PPT
HUDSON RIVER INFLOW	12000 0 CFS
RARITAN RIVER INFLOW	1770 0 CFS

LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1 ON VELOCITIES

STATION
1 V



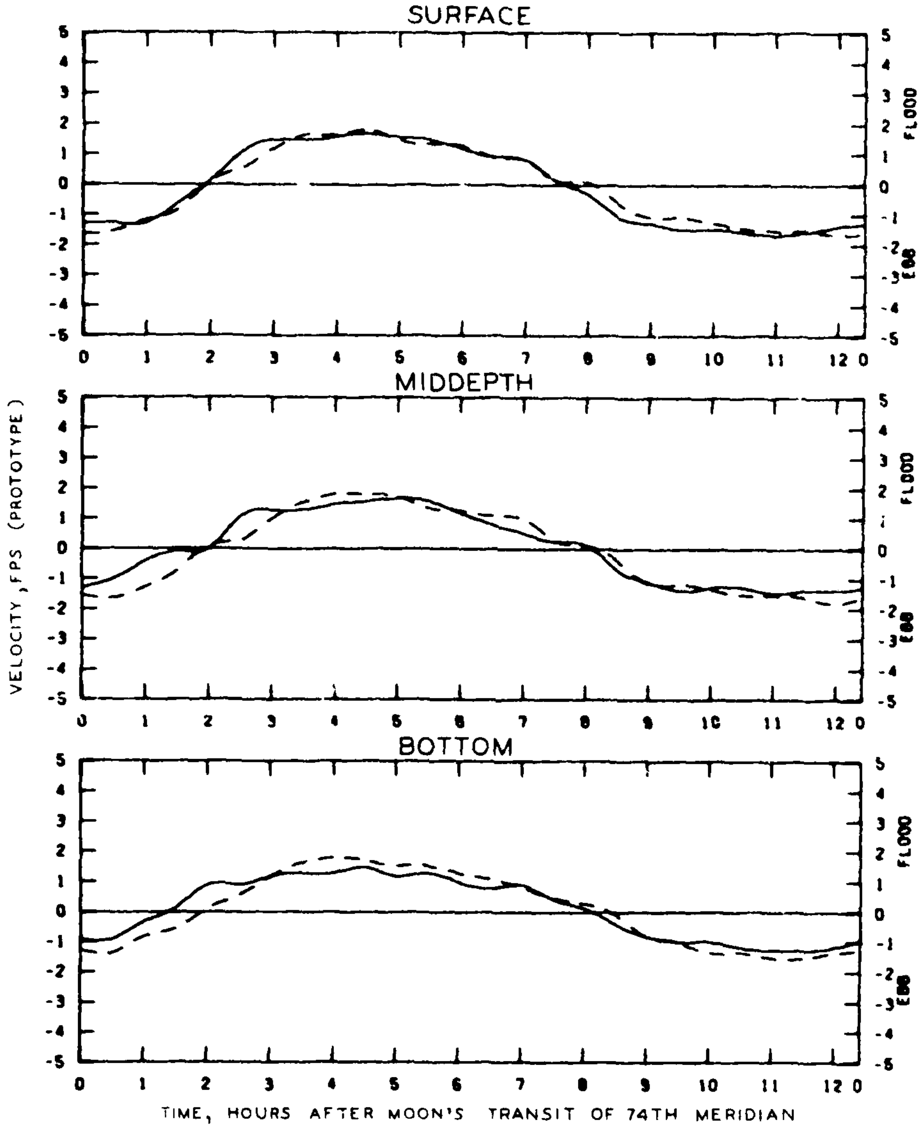
TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

LEGEND

——— BASE 1974
– – – PLAN C-1

EFFECTS OF PLAN C-1
ON VELOCITIES
STATION
2 V



TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	770.0 CFS

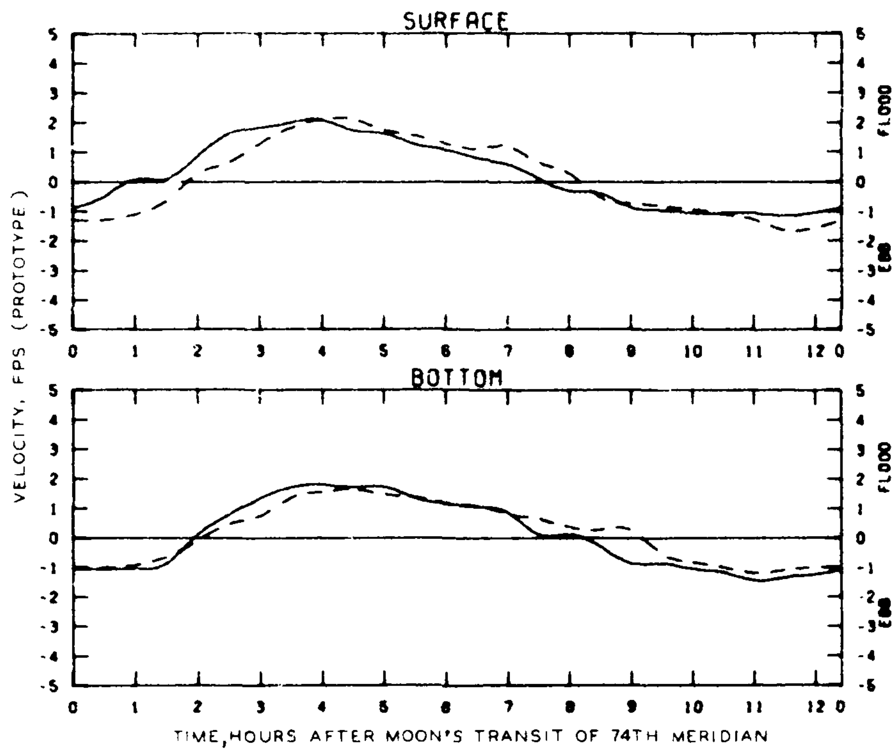
LEGEND

——— BASE 1974
— — — PLAN C-1

EFFECTS OF PLAN C-1 ON VELOCITIES

STATION

3 V



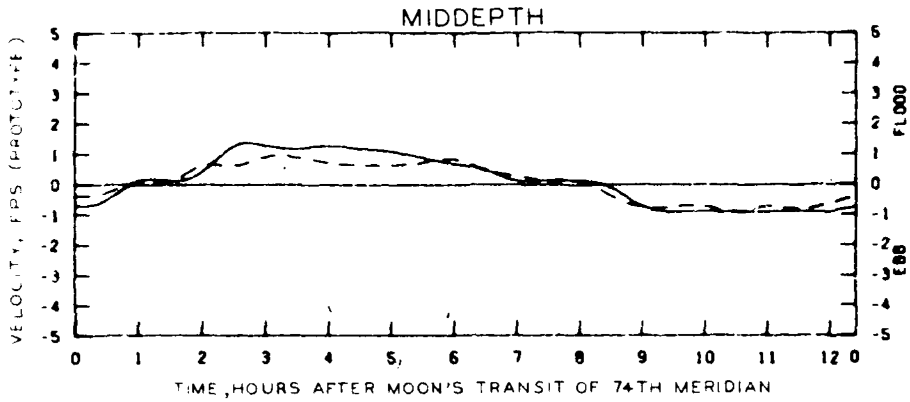
TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	770.0 CFS

LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1
ON VELOCITIES
STATION
4 V



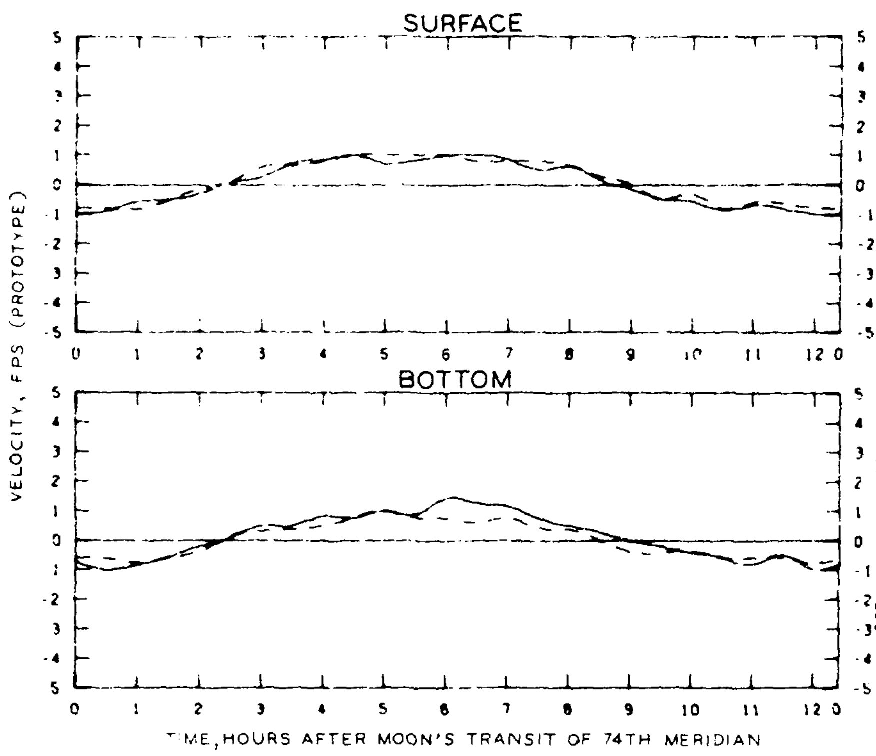
TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.[illegible] FT
OCEAN SALINITY (TOTAL SALTS)	30.0 PPT
HUDSON RIVER INFLOW	[illegible]2000.0 CFS
RARITAN RIVER INFLOW	[illegible] CFS

LEGEND

——— BASE 1974
– – – PLAN C

EFFECTS OF PLAN C-1
ON VELOCITIES
STATION
5 V



TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

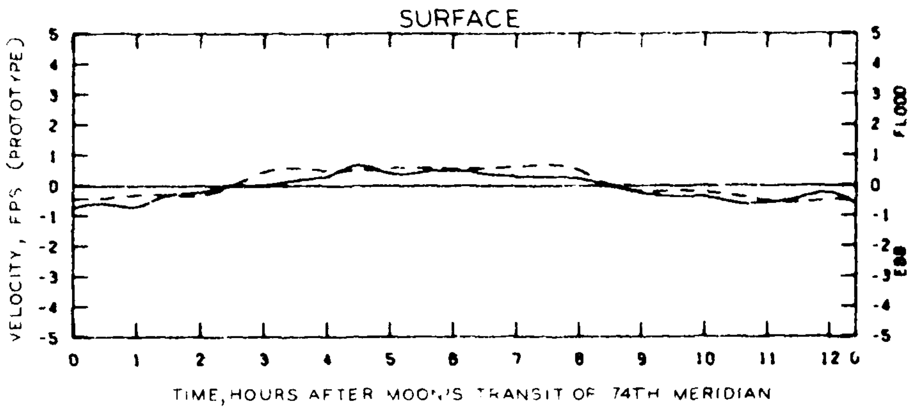
LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1
ON VELOCITIES

STATION
6 V

PLATE 115



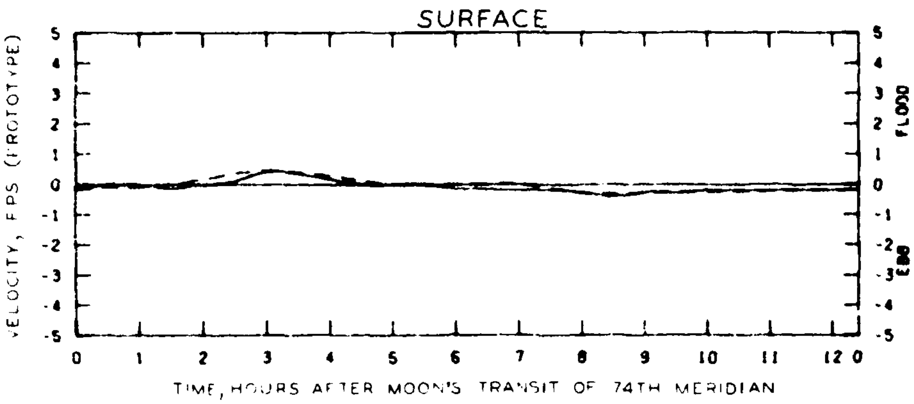
TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.[illegible] FT
OCEAN SALINITY (TOTAL SALT)	[illegible]0.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	[illegible] CFS

LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1
ON VELOCITIES
STATION
7 V



TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4 [illegible]
MEAN SALINITY (TOTAL SALT)	[illegible] PPT
HUDSON RIVER INFLOW	[illegible]
RARITAN RIVER INFLOW	[illegible]

LEGEND

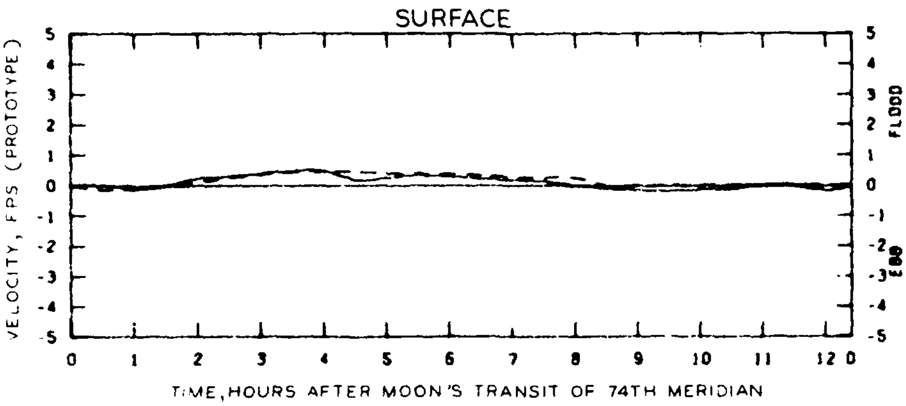
——— BASE 1974

– – – PLAN C-1

EFFECTS OF PLAN C-1 ON VELOCITIES

STATION

8V



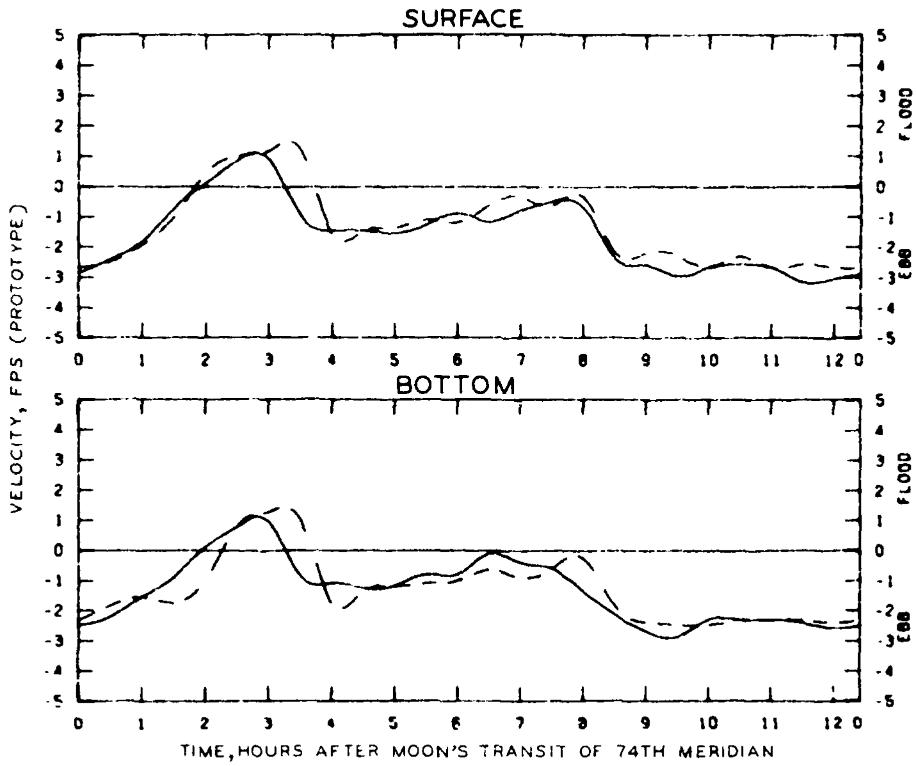
TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	[illegible]0.[illegible] PPT
HUDSON RIVER INFLOW	[illegible]2000.0 CFS
RARITAN RIVER INFLOW	[illegible]770.0 CFS

LEGEND

——— BASE [illegible]974
– – – – PLAN C-[illegible]

EFFECTS OF PLAN C-1
ON VELOCITIES
STATION
9V



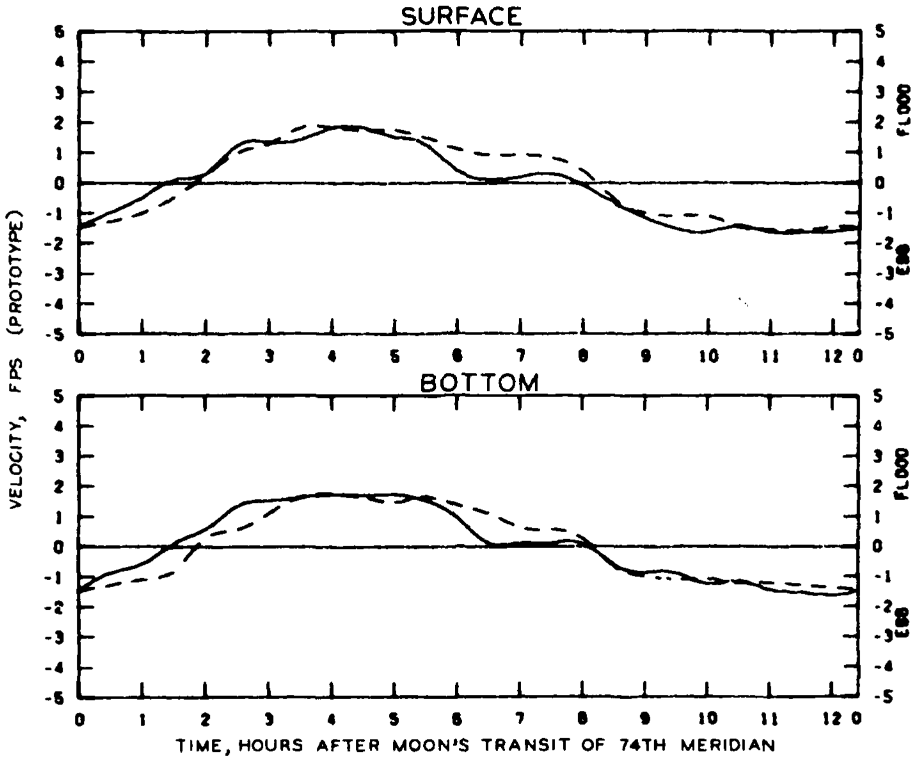
TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	[illegible]70.0 CFS

LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1
ON VELOCITIES
STATION
1 OC



TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

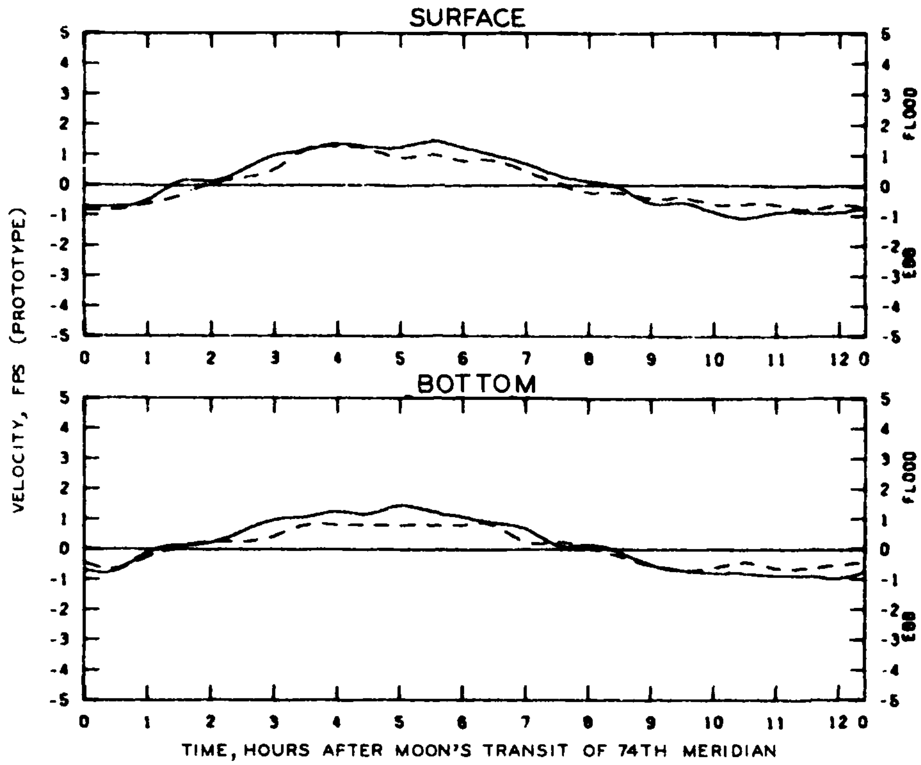
LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1 ON VELOCITIES

STATION

3 OC



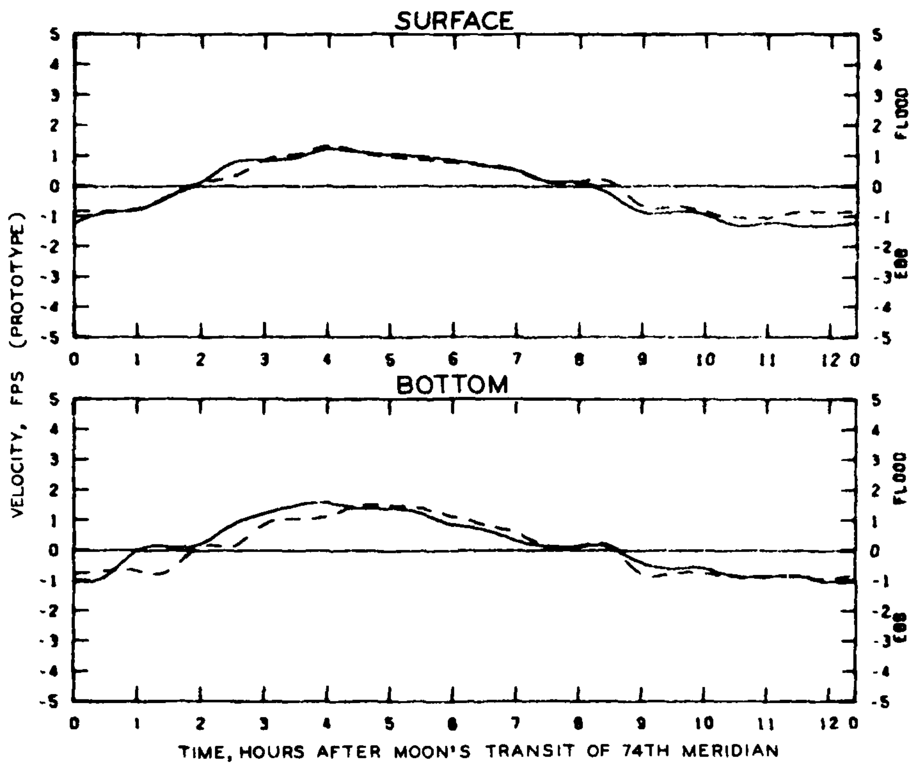
TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1
ON VELOCITIES
STATION
0 BCH



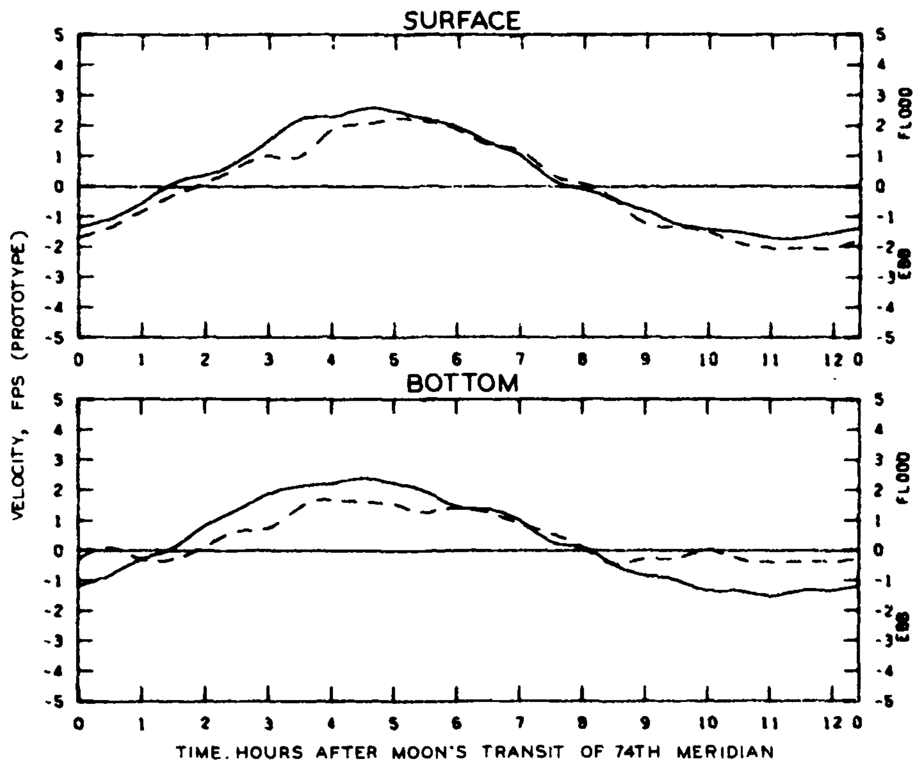
TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1
ON VELOCITIES
STATION
1 BCH



TEST CONDITIONS

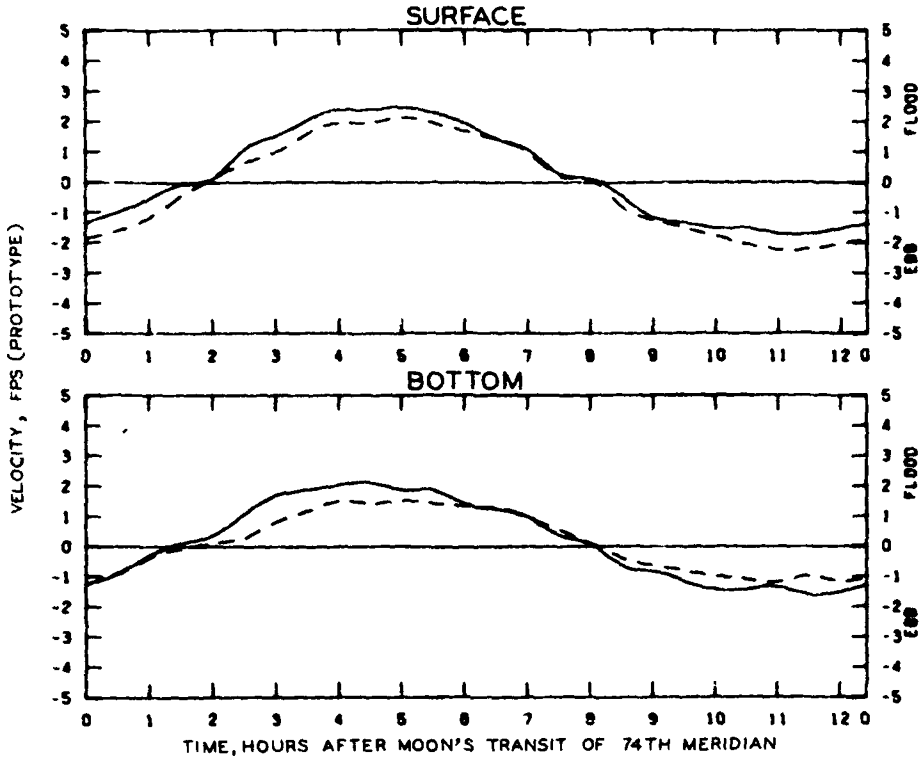
TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1
ON VELOCITIES

STATION
14 V



TEST CONDITIONS

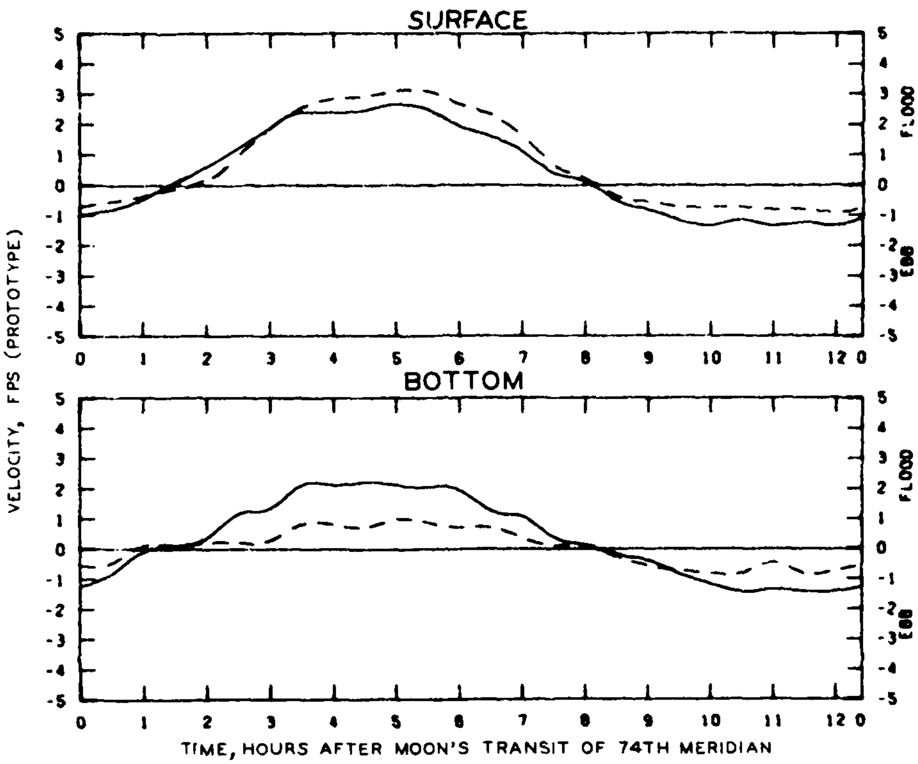
TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1
ON VELOCITIES
STATION
15 V

PLATE 124



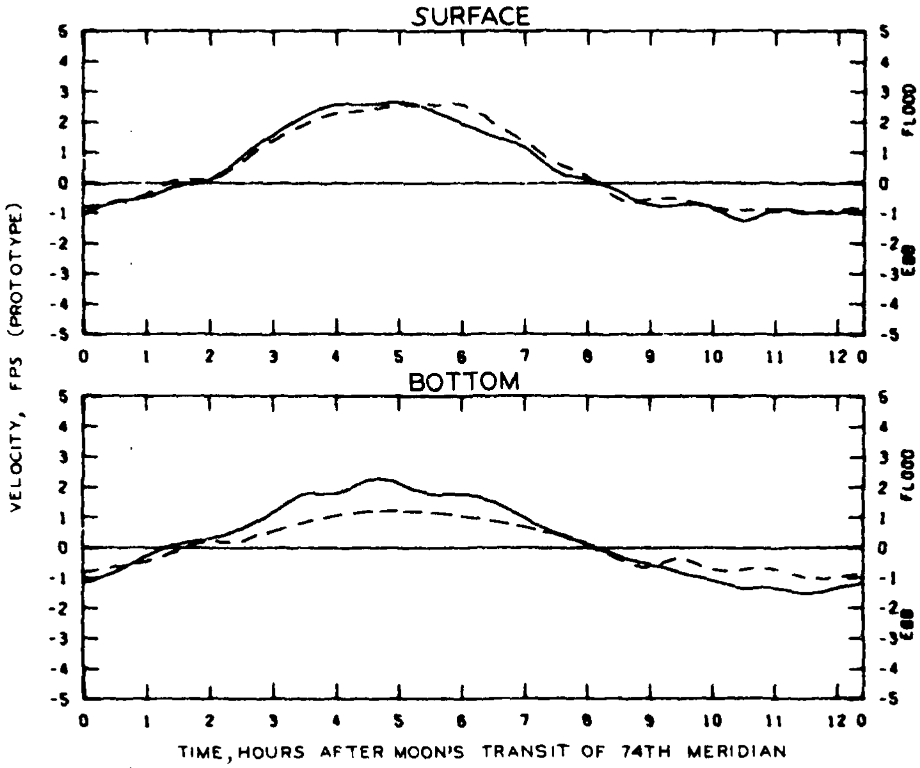
TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1
ON VELOCITIES
STATION
18 V



TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

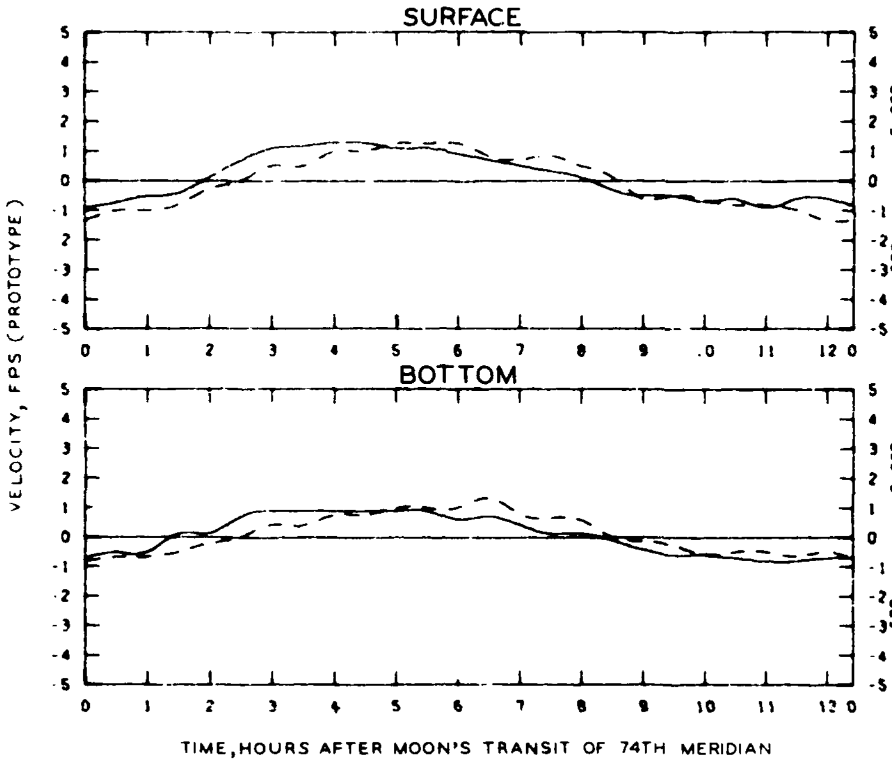
LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1 ON VELOCITIES

STATION

17 V



TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

LEGEND

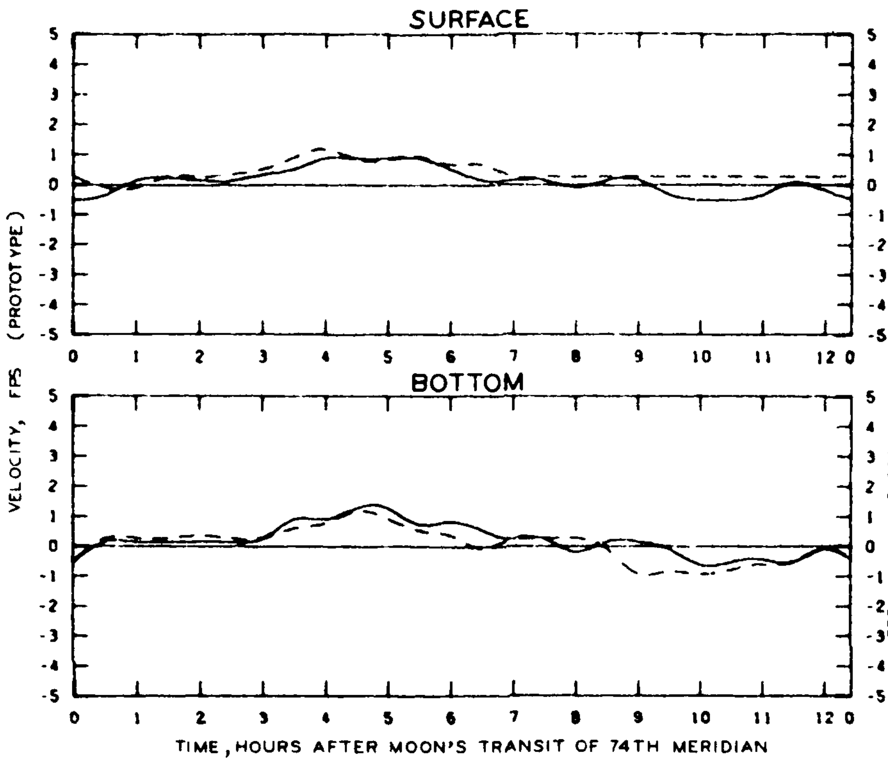
——— BASE 1974

- - - - PLAN C-1

EFFECTS OF PLAN C-1 ON VELOCITIES

STATION

4 BCH



TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

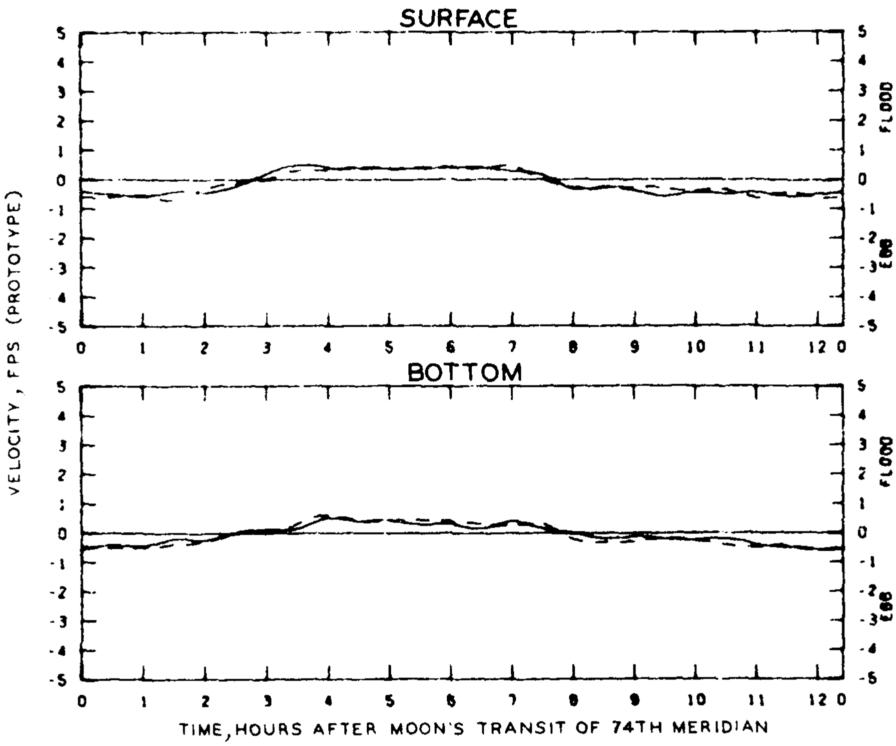
LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1 ON VELOCITIES

STATION

7 ICH



TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	770.0 CFS

LEGEND

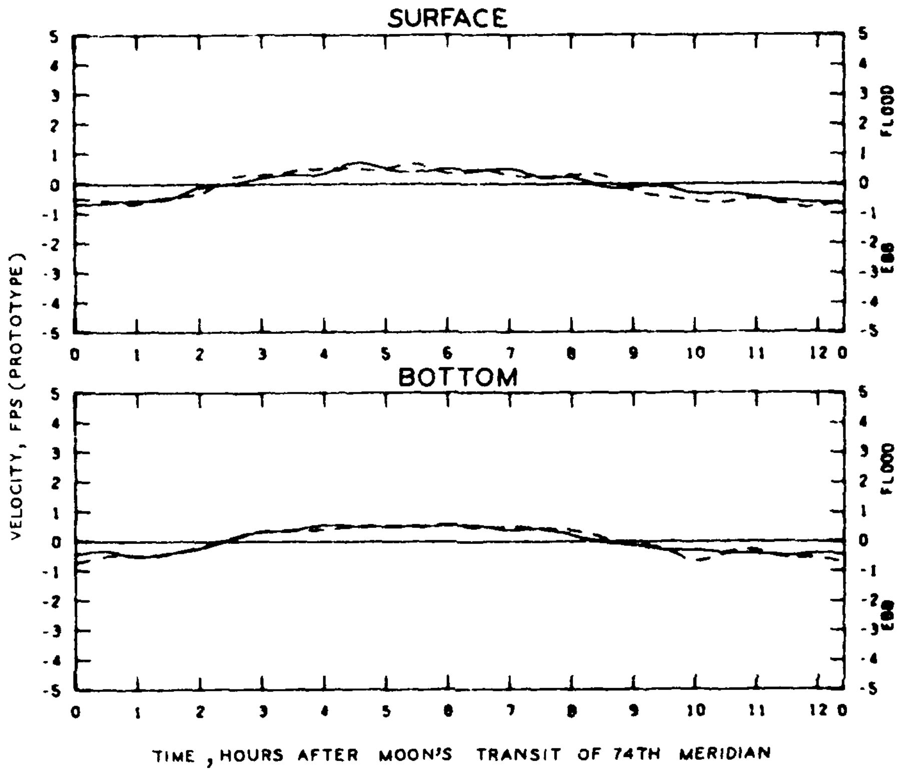
BASE 1974

PLAN C-1

EFFECTS OF PLAN C-1 ON VELOCITIES

STATION

9 ICH



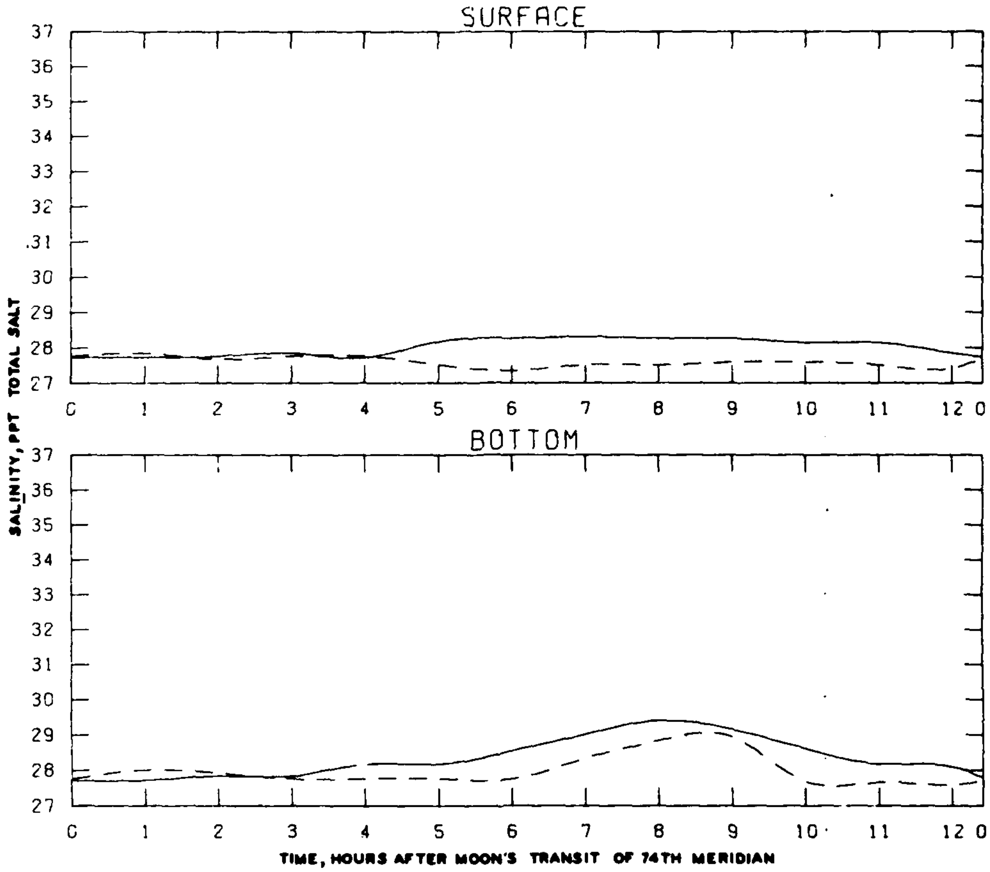
TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1
ON VELOCITIES
STATION
11.1 CH



TEST CONDITIONS

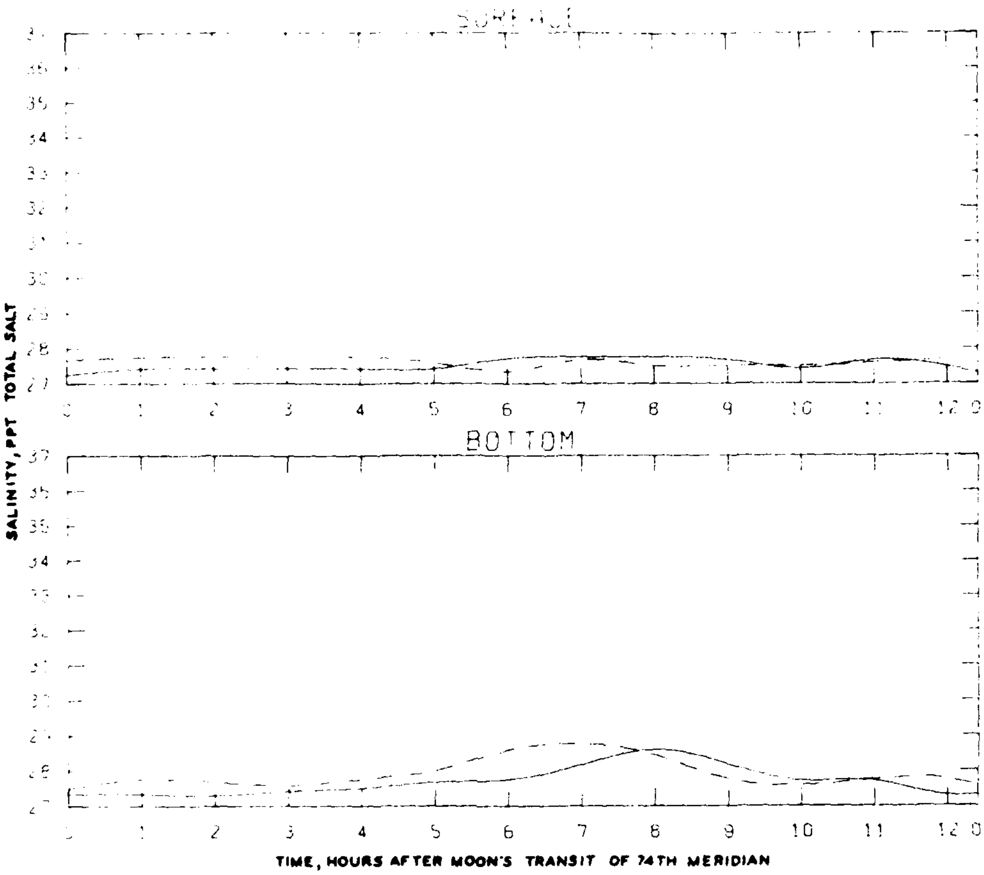
TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1 ON SALINITIES

STATION IV



TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

LEGEND

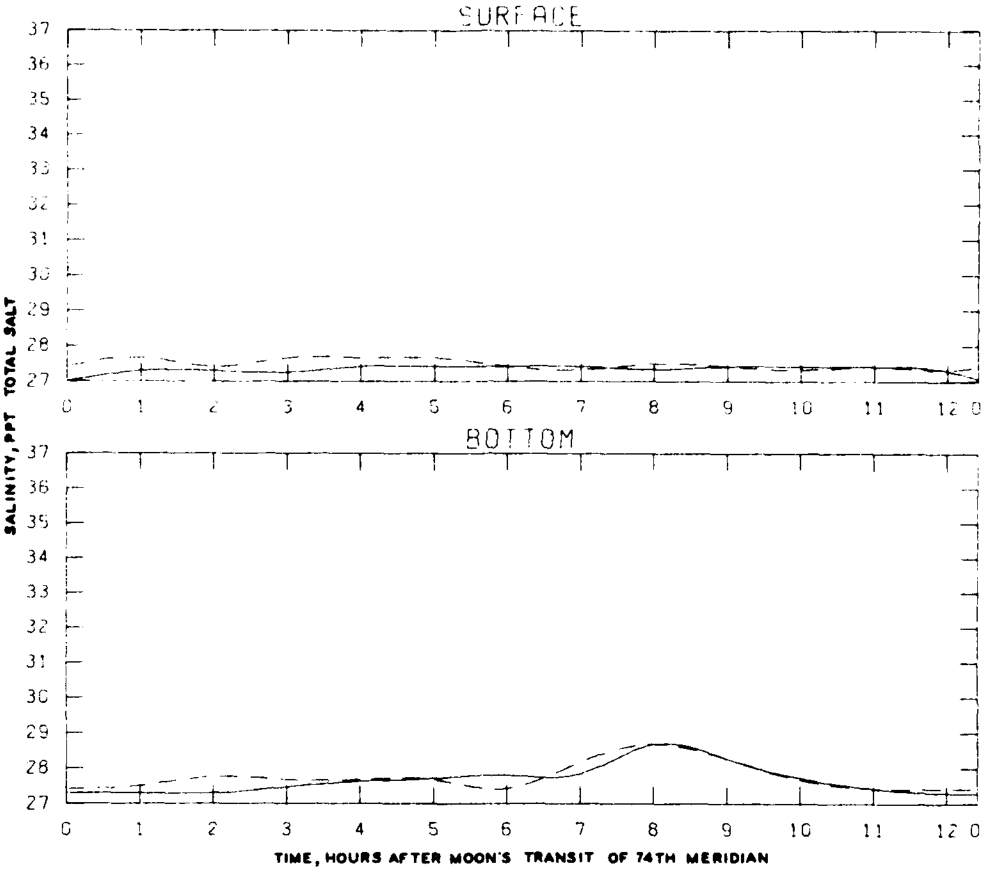
——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1 ON SALINITIES

STATION

2V

PLATE 132



TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

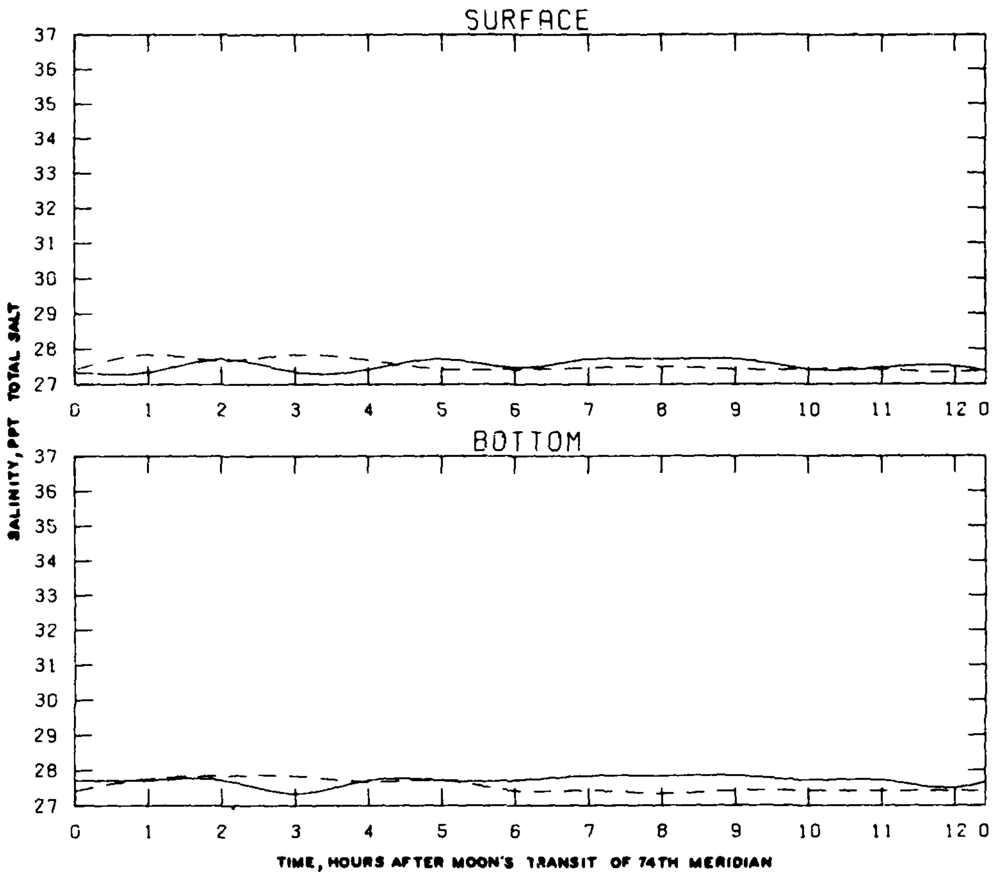
LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1 ON SALINITIES

STATION

3V



TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

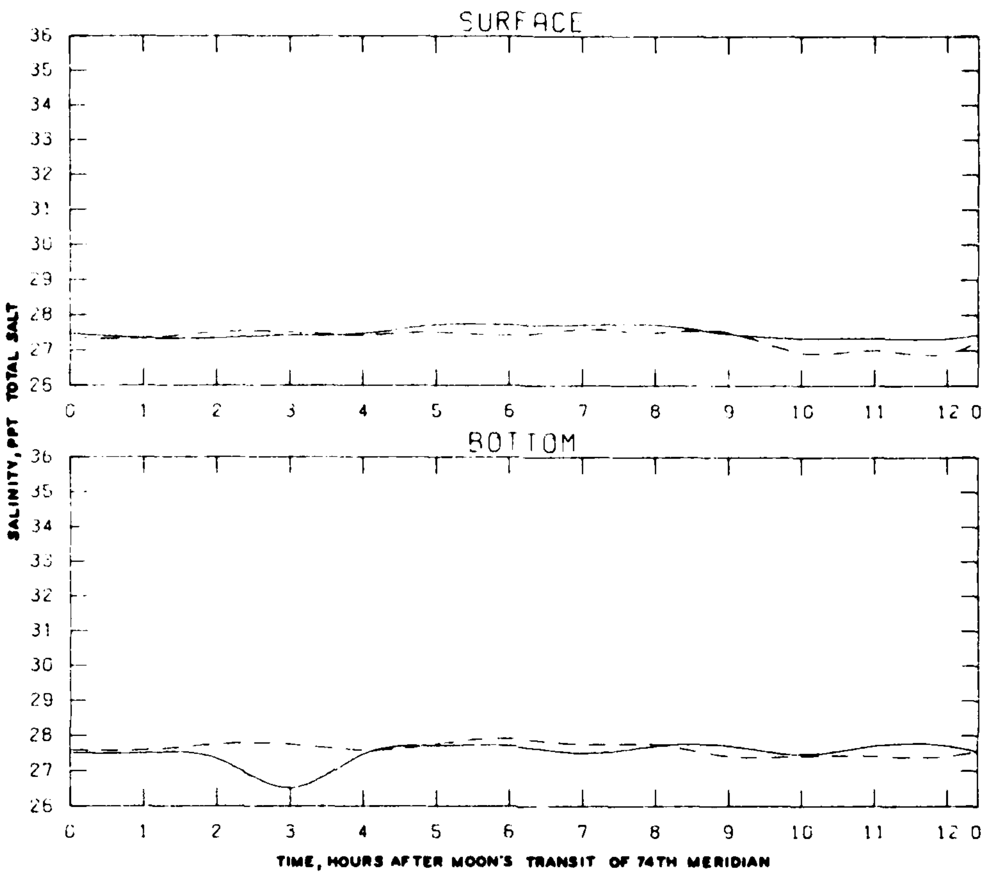
LEGEND

———— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1 ON SALINITIES

STATION

4 V



TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

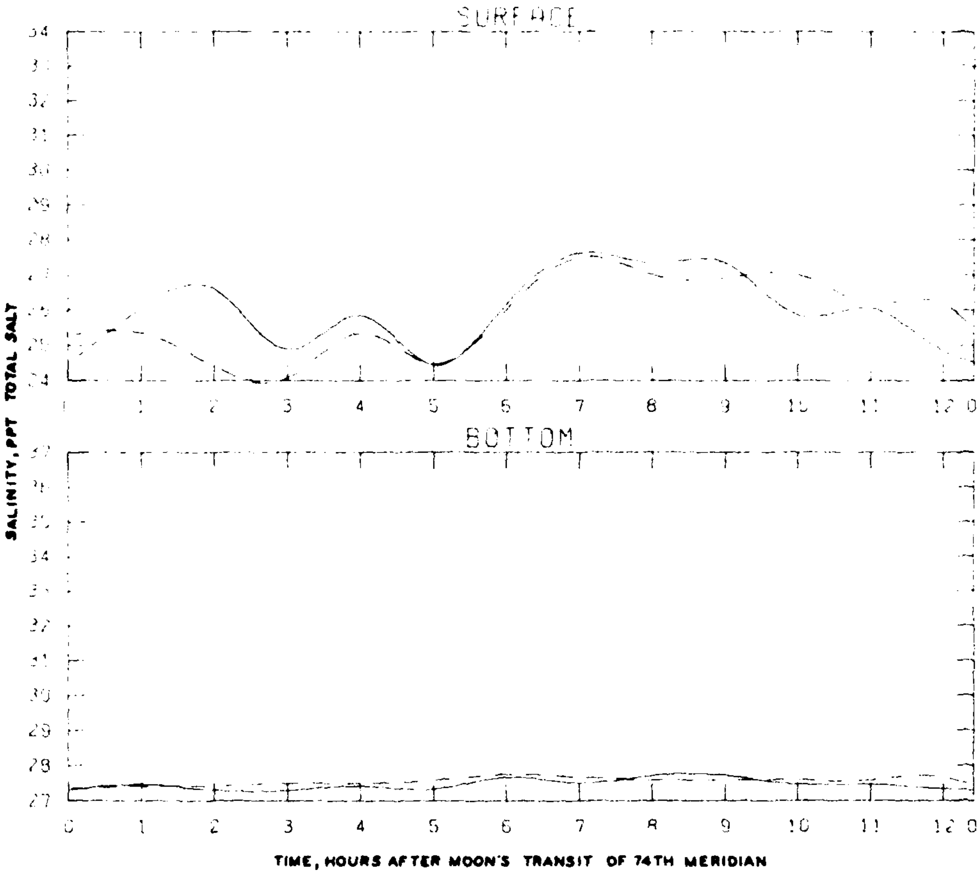
LEGEND

——— BASE 1974
- - - - PLAN C-1

EFFECTS OF PLAN C-1 ON SALINITIES

STATION

5V



TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

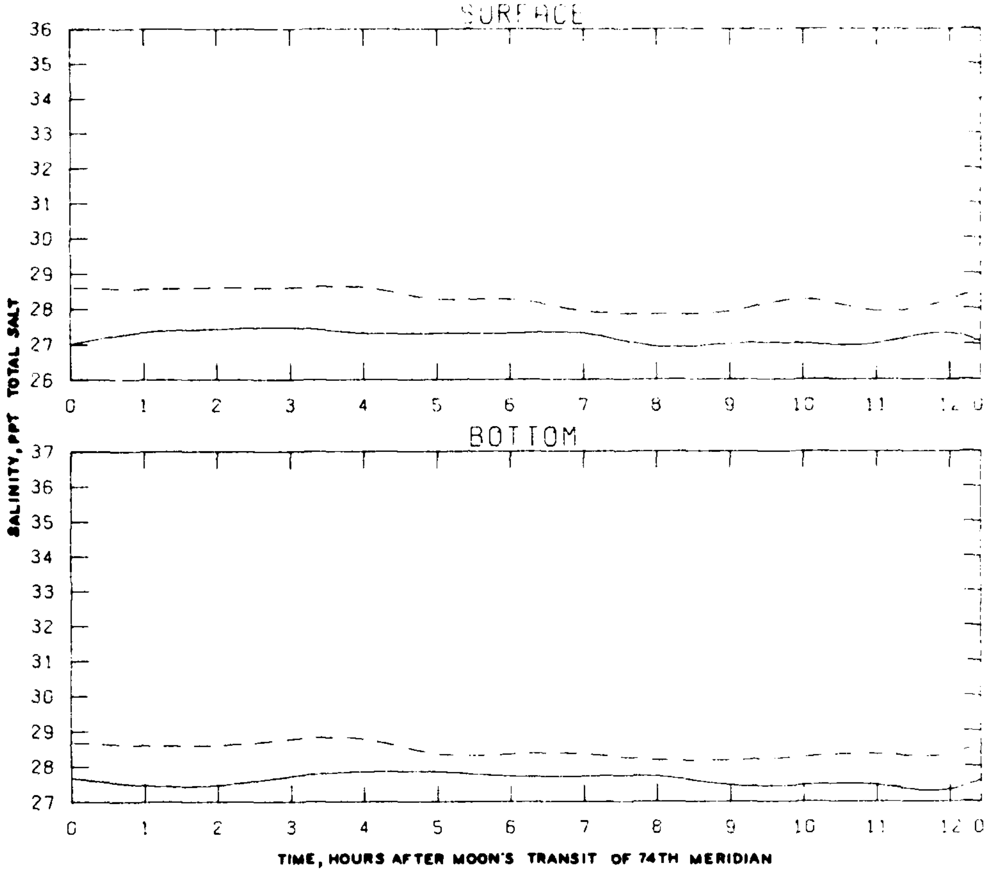
LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1 ON SALINITIES

STATION

6V



TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

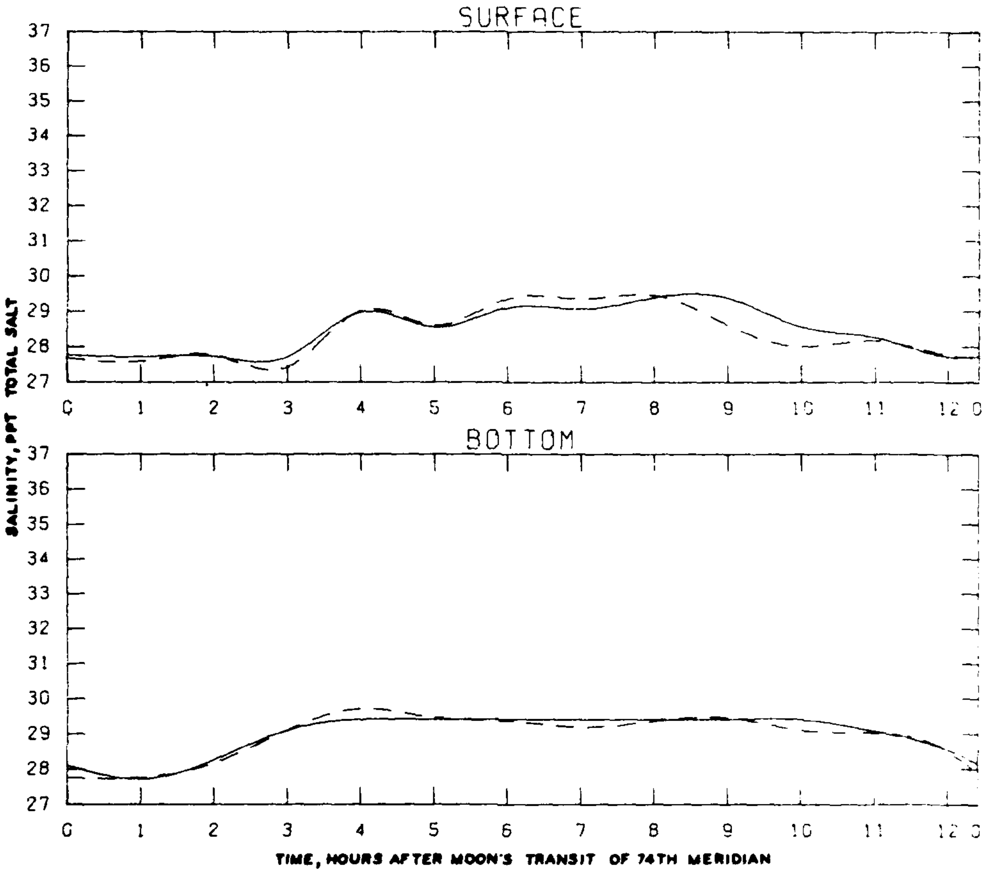
LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1 ON SALINITIES

STATION

7V



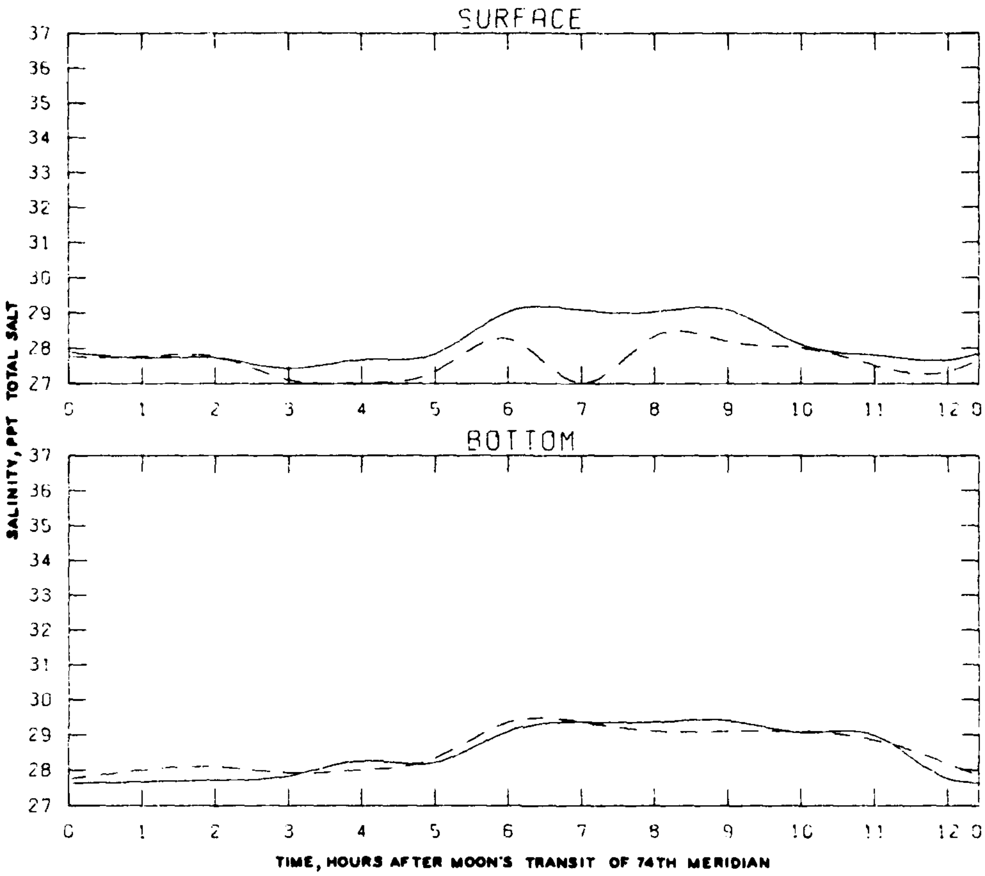
TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1
ON SALINITIES
STATION
1 OC



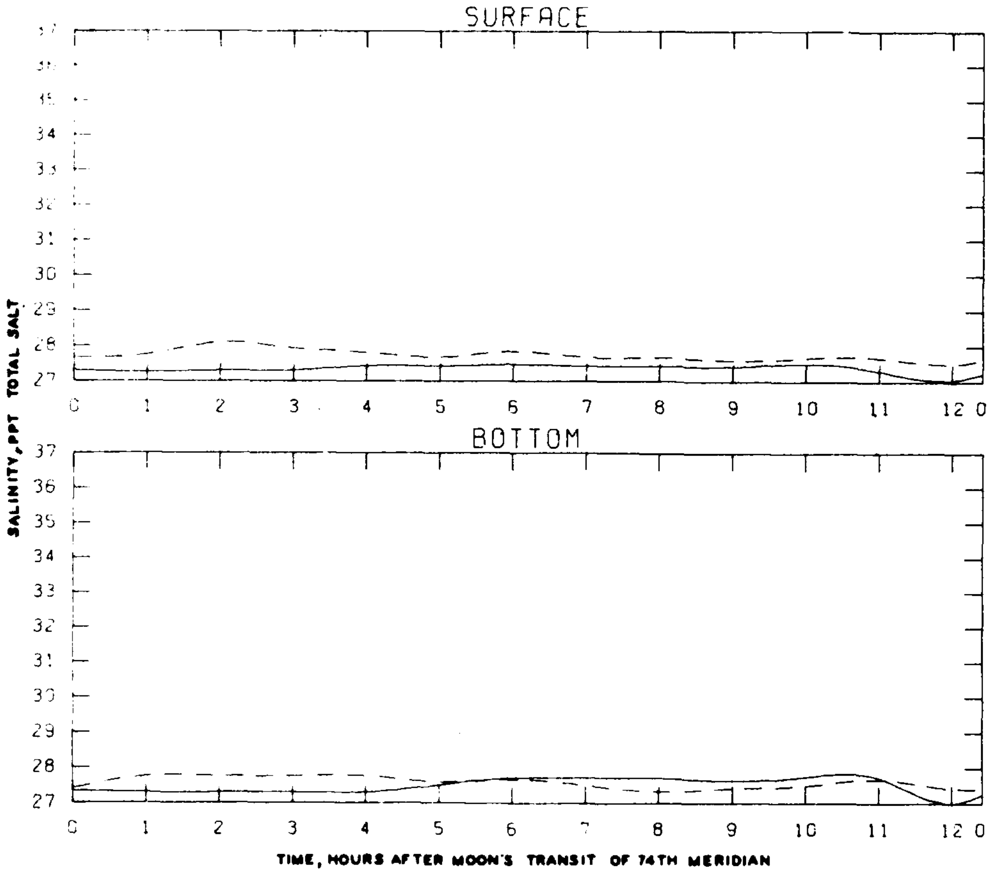
TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1
ON SALINITIES
STATION
3 OC



TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4 7 FT
OCEAN SALINITY (TOTAL SALT)	30 0 PPT
HUDSON RIVER INFLOW	12000 0 CFS
RARITAN RIVER INFLOW	1770 0 CFS

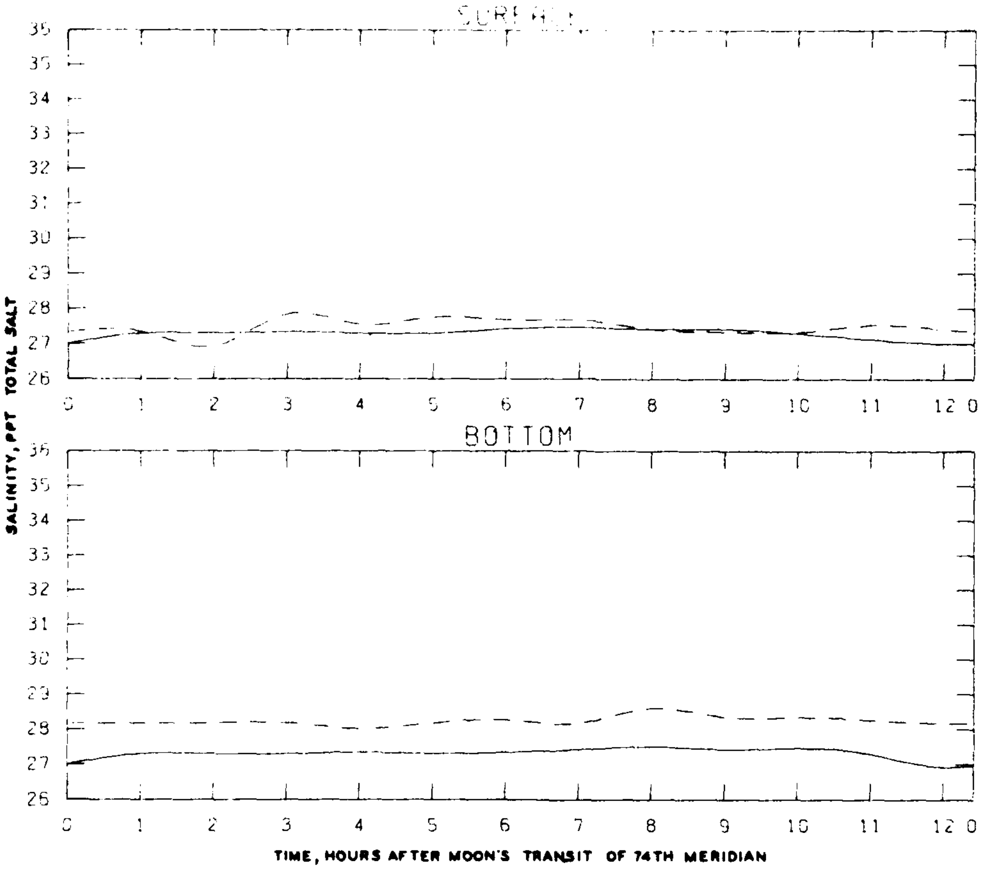
LEGEND

——— BASE 1974
- - - - PLAN C-1

EFFECTS OF PLAN C-1 ON SALINITIES

STATION

0 BCH



TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

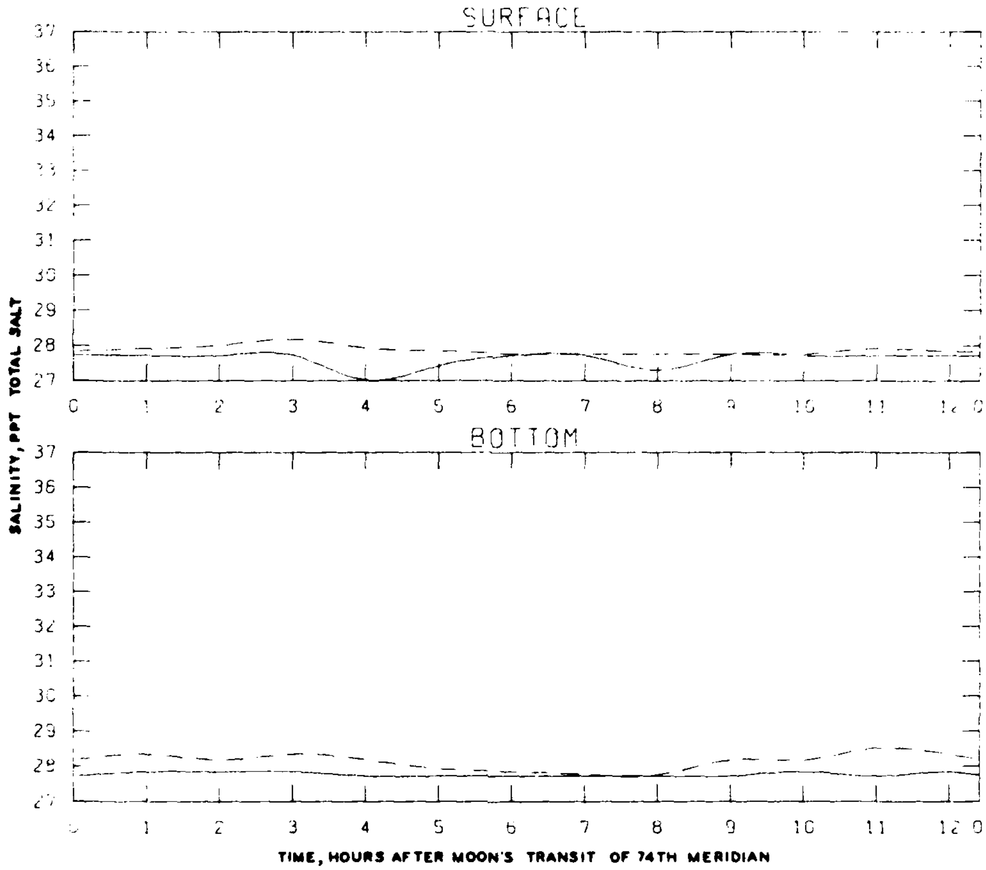
LEGEND

——— BASE 1974
- - - - PLAN C-1

EFFECTS OF PLAN C-1 ON SALINITIES

STATION

1 BCH



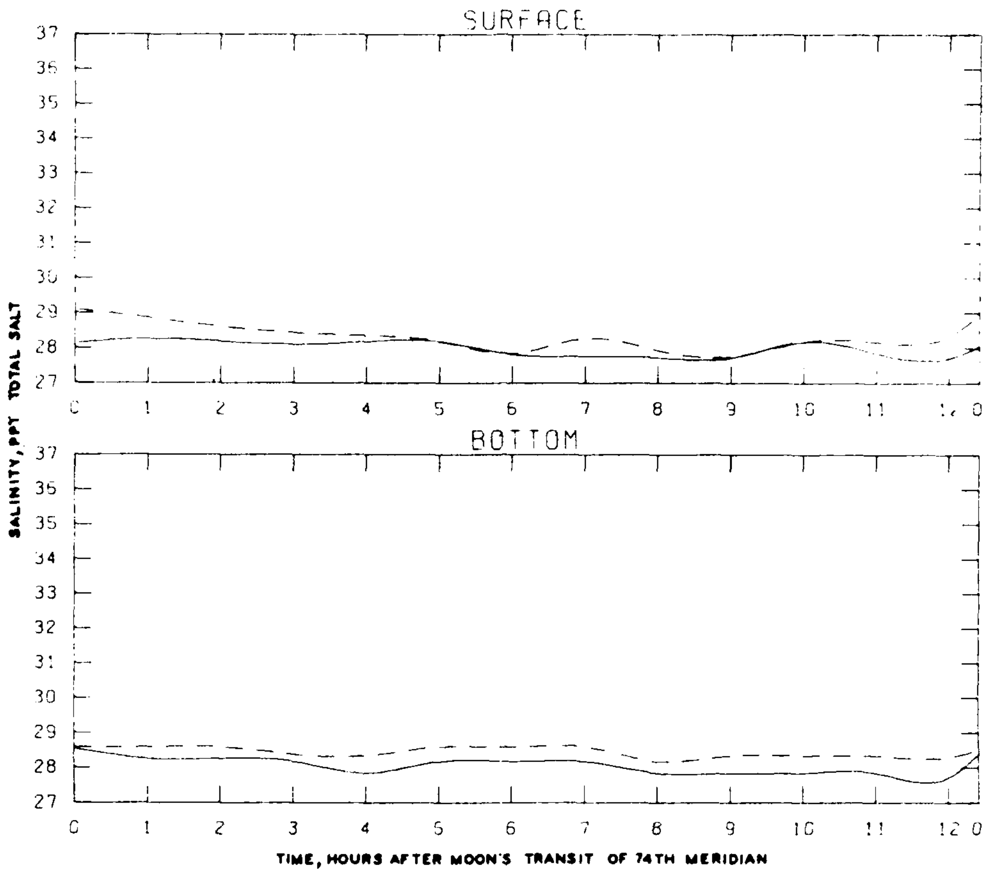
TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

LEGEND

——— BASE 1974
- - - - PLAN C-1

EFFECTS OF PLAN C-1
ON SALINITIES
STATION
4 BCH



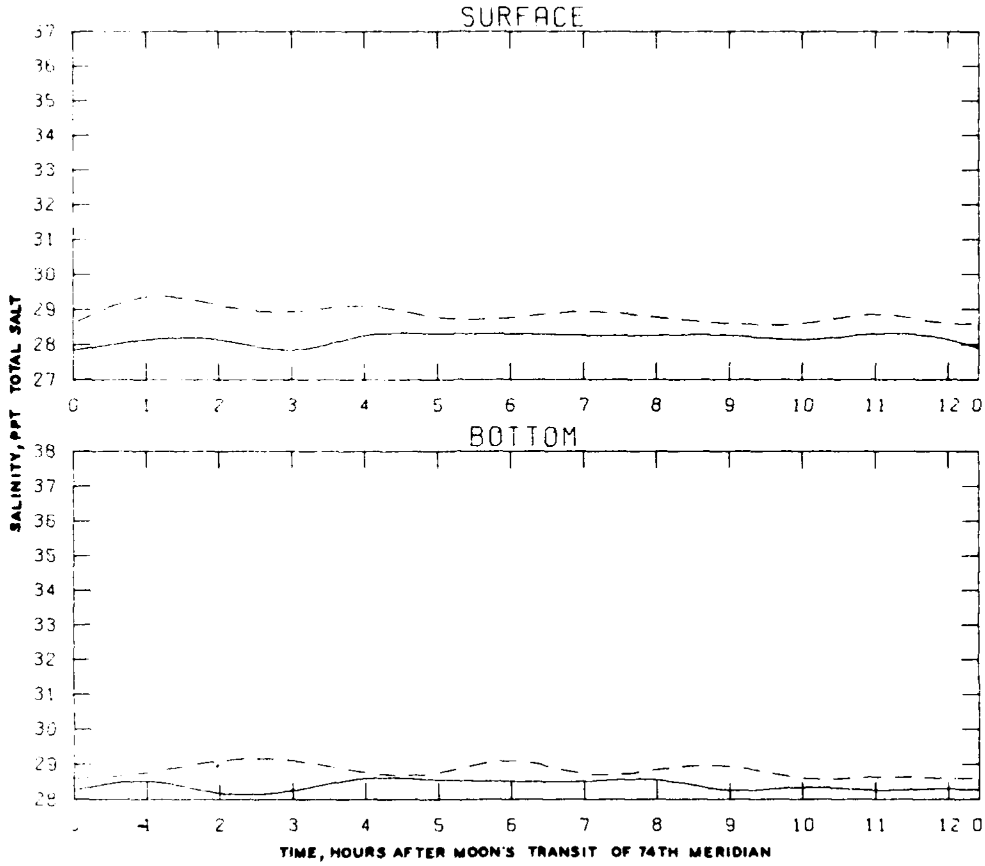
TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

LEGEND

——— BASE 1974
- - - - PLAN C-1

EFFECTS OF PLAN C-1
ON SALINITIES
STATION
6 BCH



TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

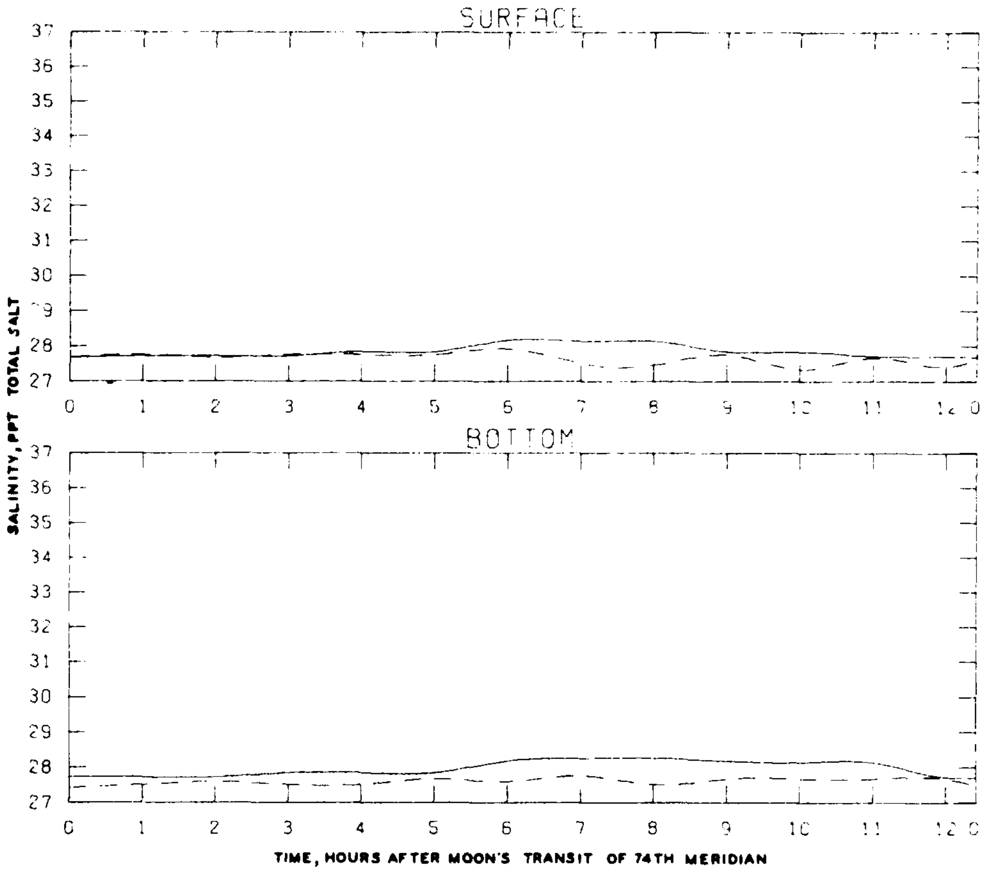
LEGEND

——— BASE 1974
- - - - PLAN C-1

EFFECTS OF PLAN C-1 ON SALINITIES

STATION

8 BCH



TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

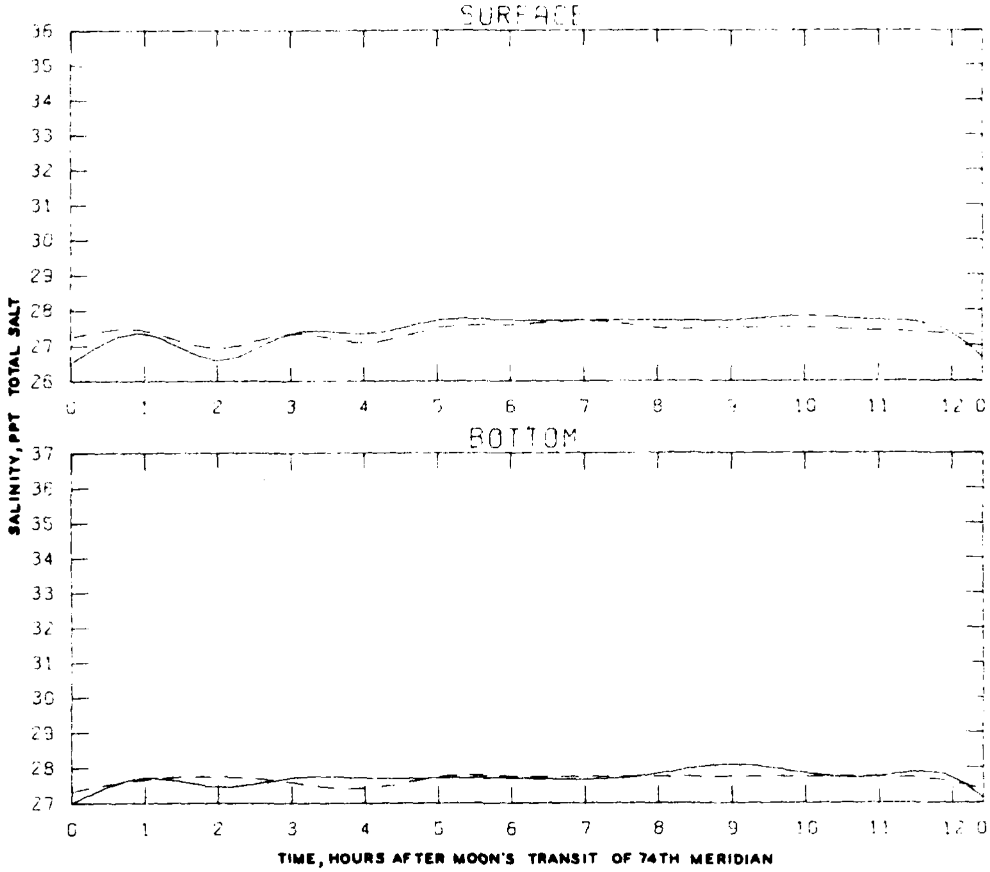
LEGEND

———— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1 ON SALINITIES

STATION

7 ICH



TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

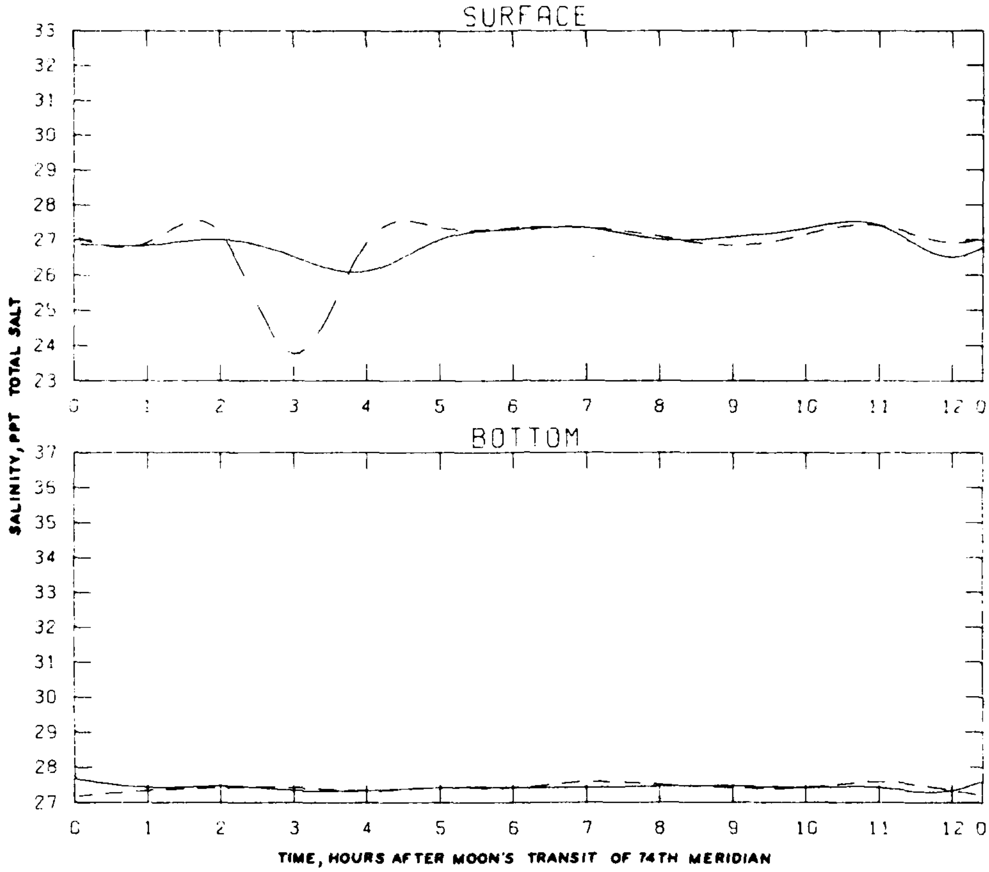
LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1 ON SALINITIES

STATION

9 ICH



TEST CONDITIONS

TIDAL RANGE AT SANDY HOOK	4.7 FT
OCEAN SALINITY (TOTAL SALT)	30.0 PPT
HUDSON RIVER INFLOW	12000.0 CFS
RARITAN RIVER INFLOW	1770.0 CFS

LEGEND

——— BASE 1974
– – – – PLAN C-1

EFFECTS OF PLAN C-1 ON SALINITIES

STATION

11 ICH

APPENDIX A: BARRIER PLANS C-1 AND C-3

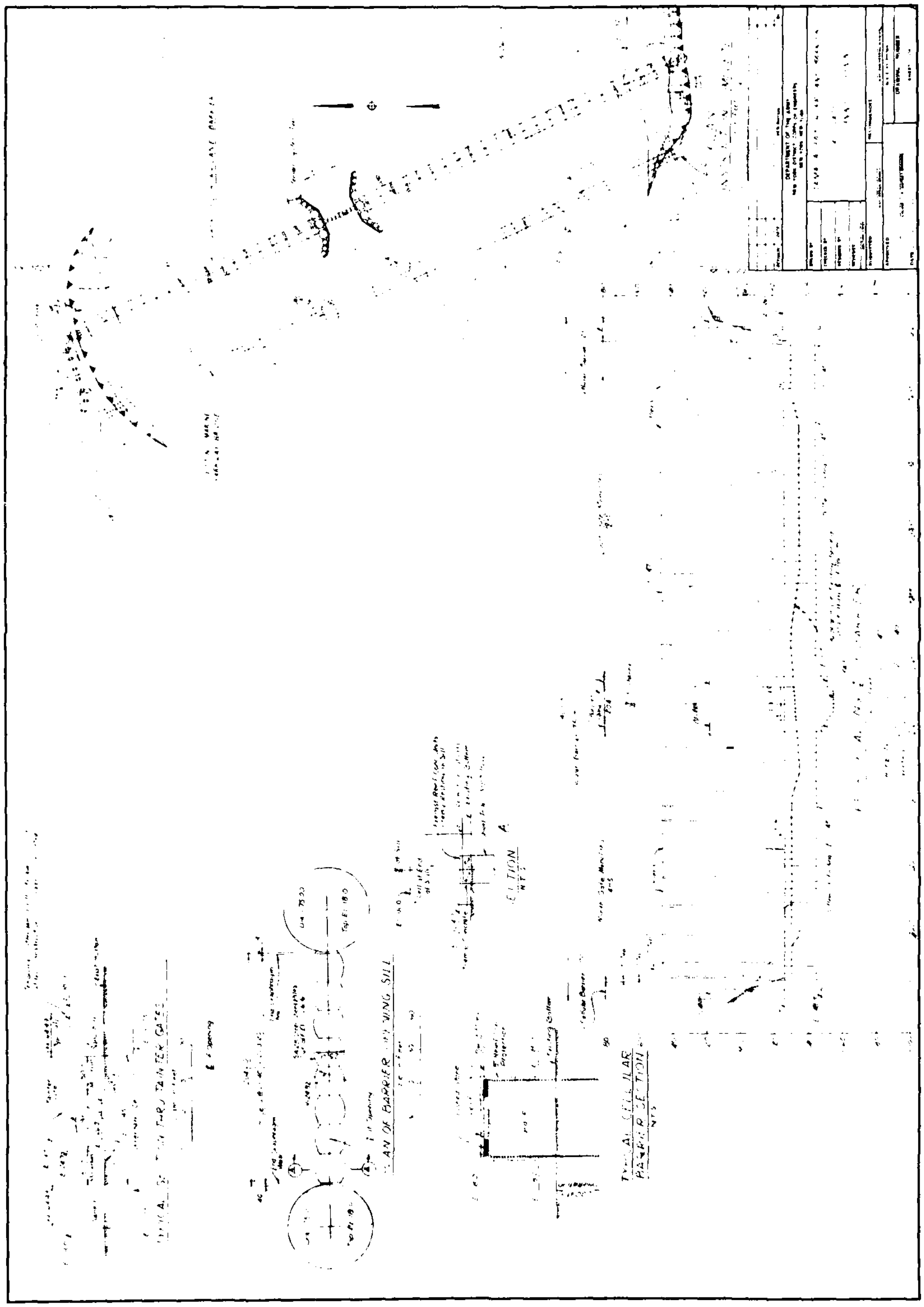


PLATE A1

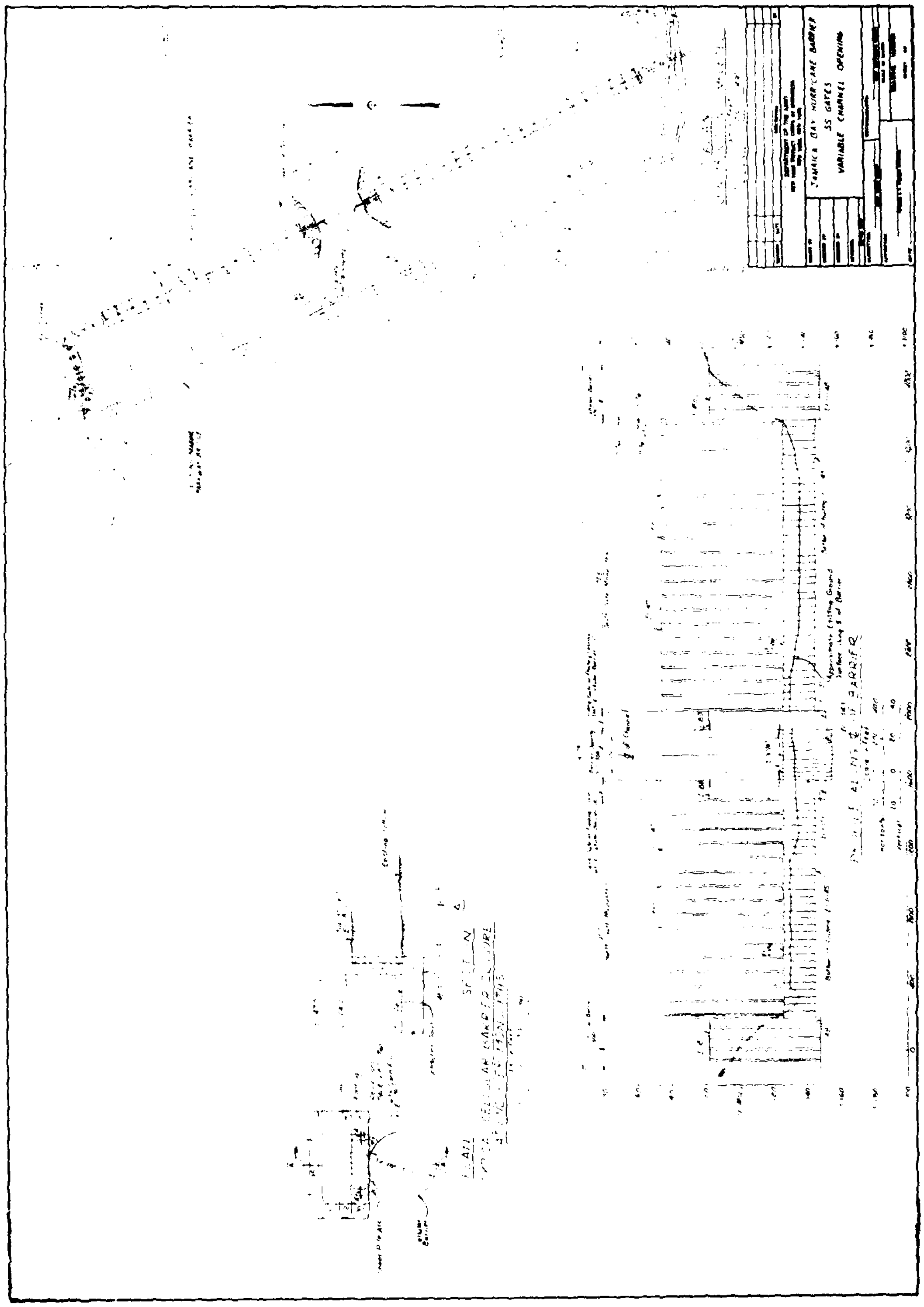

JAMAICA BAY HURRICANE BARRIER
SS GATES
VARIABLE CHANNEL OPENING

PLATE A2

In accordance with ER 70-2-3, paragraph 6c(1)(b), dated 15 February 1973, a facsimile catalog card in Library of Congress format is reproduced below.

Athow, Robert F
Effects of hurricane surge barrier on hydraulic environment, Jamaica Bay, New York; hydraulic model investigation, by Robert F. Athow, Jr. Vicksburg, U. S. Army Engineer Waterways Experiment Station, 1976.
1 v. (various pagings) illus. 27 cm. (U. S. Waterways Experiment Station. Technical report H-76-14)
Prepared for U. S. Army Engineer District, New York, New York, New York.
Includes bibliography.

1. Hurricane barriers. 2. Hydraulic models. 3. Jamaica Bay, New York. 4. Surges. I. U. S. Army. Corps of Engineers. (Series: U. S. Waterways Experiment Station. Technical report H-76-14)
TA7.W34 no.H-76-14